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ORGANIZATIONAL, DS, GS, AND DEPOT MAINTENANCE MANUAL

SWEEP SIGNAL GENERATOR ALFRED ELECTRONICS, 630 SERIES

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HEADQUARTERS, DEPARTMENT OF THE ARMY

AUGUST 1967

69/40

WARNING

DANGEROUS VOLTAGES

EXIST IN THIS EQUIPMENT

Be careful when working on the power supplies and their circuits, or on the 115-volt ac line connections.

DON'T TAKE CHANCES!

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Section I. INTRODUCTION

1-A.1.Scope

This manual includes installation and operation instructions and covers operator's, organizational, direct support (DS), general support (GS), and depot maintenance. It describes Alfred Electronics (Federal Supply Code 03782) Sweep Signal Generator, 630 series. A basic issue items list for this equipment is not included as part of this manual.

1-A.2. Index of Publications

Refer to the latest issue of DA Pam 310-4 to determine whether there are new editions, changes, or additional publications pertaining to the equipment.

1-A.3. Forms and Records

a. Reports of Maintenance and Unsatisfactory Equipment. Use equipment forms and records in accordance with instructions given in TM 38-750.

b. Report of Packaging and Handling Deficiencies. Fill out and forward DD Form 6 (Report of Packaging and Handling Deficiencies) as prescribed in AR 700-58 (Army), NAVSUP Publication 378 (Navy), AFR 71-4 (Air Force), and MCO P4610 (Marine Corps).

c. Discrepancy in Shipment Report (DISREP) (SF361). Fill out and forward Discrepancy in Shipment Report (DISREP) (SF361) as prescribed in AR 55-38 (Army), NAVSUP Pub 459 (Navy), AFM 75-34 (Air Force), and MCO P4610.19 (Marine Corps).

d. Reporting of Equipment Manual Improvements. Report of errors, omissions, and recommendations for improving this manual by the individual user is encouraged. Reports should be submitted on DA Form 2028 (Recommended Changes to DA Publications) and forwarded direct to Commanding General, U. S. Army Electronics Command, ATTN: AMSEL-ME-NMP-AD, Fort Monmouth, N.J. 07703.

1.1 SPECIFICATIONS

MODEL	FREQUENCY RANGE	LEVELED OUTPUT POWER	POWER VARIATION	RESIDUAL AM	RESIDUAL FM MAXIMUM	VSWR	RF CONNECTOR
631 A	1 to 2 Gc	More than 50 mw	±0.3 db	Non-harmonics 40 db and harmonics 20 db below signal level.	25 Kc peak unleveled. 50 Kc peak leveled.	Less than 2.5 : 1	Type 'N' Female
631A-S1	1.4 to 2.5 Gc	More than 50 mw	±0.3 db	Non-harmonics 40 db and harmonics 20 db below signal level.	25 Kc peak unleveled. 50 Kc peak leveled.	Less than 2.5 : 1	Type 'N' Female
632A	2 to 4 Gc	More than 40 mw	±0.3 db	Non-harmonics 40 db and harmonics 20 db below signal level.	25 Kc peak unleveled. 50 Kc peak leveled.	Less than 2.5 : 1	Type 'N' Female
633A-S1	3.5 to 6.75 Gc	More than 10 mw	±0.5 db	40 db below signal level.	60 Kc peak unleveled. 80 Kc peak leveled.	Less than 2.5 : 1	Type 'N' Female
633A	4 to 8 Gc	More than 20 mw	±0.5 db	40 db below signal level.	60 Kc peak unleveled. 80 Kc peak leveled.	Less than 2.5 : 1	Type 'N' Female
634A	7 to 11 Gc	More than 10 mw	±0.5 db	40 db below signal level	75 Kc peak unleveled. 100 Kc peak leveled.	Less than 2.5 : 1	Type 'N' Female
635A	8 to 12.4 Gc	More than 20 mw	±0.5 db from 8.2 to 12.4 Gc	40 db below signal level	75 Kc peak unleveled. 100 Kc peak leveled.	Less than 2.5 : 1	UG135/U Flange
637A	12.4 to 18 Gc	More than 10 mw	±0.75 db	40 db below signal level.	100 Kc peak unleveled. 150 Kc peak leveled.	Less than 2.5 : 1	UG419/U Flange

MODEL	FREQUENCY RANGE	POWER OUTPUT	LEVELED OUTPUT POWER VARIATION	RESIDUAL AM	RESIDUAL FM MAXIMUM
631D	1 to 2 Gc	+ 13 dbm to - 40 dbm	Less than ±0.5 db from + 13 dbm to - 10 dbm; less than ±2.0 db at - 40 dbm.	Non-harmonics 40 db and harmonics 20 db below signal level.	25 Kc peak unleveled. 50 Kc peak leveled.
631D-S1	1.4 to 2.5 Gc	+ 13 dbm to - 40 dbm	Less than ±0.5 db from + 13 dbm to - 10 dbm; less than ±2.0 db at - 40 dbm.	Non-harmonics 40 db and harmonics 20 db below signal level.	25 Kc peak unleveled. 50 Kc peak leveled.
632D	2 to 4 Gc	+ 10 dbm to - 40 dbm	Less than ±0.5 db from + 10 dbm to - 10 dbm; less than ±2.0 db at - 40 dbm.	Non-harmonics 40 db and harmonics 20 db below signal level.	25 Kc peak unleveled. 50 Kc peak leveled.
633D	4 to 8 Gc	+ 8 dbm to - 45 dbm	Less than ±0.5 db from + 8 dbm to - 12 dbm; less than ±2.0 db at - 45 dbm.	Non-harmonics 40 db and harmonics 20 db below signal level.	60 Kc peak unleveled. 80 Kc peak leveled.
633D-S1	3.5 to 6.75 Gc	+ 8 dbm to - 45 dbm	Less than ±0.5 db from + 8 dbm to - 12 dbm; less than ±2.0 db at - 45 dbm.	Non-harmonics 40 db and harmonics 20 db below signal level.	60 Kc peak unleveled. 80 Kc peak leveled.

Frequency Control:	Three controls continuously adjustable over entire frequency range. F_1 for start frequency, F_2 for end frequency and F_0 for symmetrical narrow sweep. All three can be used for single frequency operation. Frequency calibration better than 1% (leveled operation).
Frequency Stability:	Better than 0.01% per degree centigrade.
RF Power Calibration:	Within ± 0.25 db plus leveled power variation.
Marker Control:	Three markers (M_1 , M_2 , and F_0) continuously adjustable over entire frequency range. Marker calibration: better than 1% (leveled operation). Marker width: approximately 0.05% of frequency range. Marker appears as a reduction of rf power and is adjustable from zero to greater than 10%.
Wide Sweep: ($F_1 \rightarrow F_2$)	Continuously adjustable from 2% to 100% of the full band range.
Symmetrical Sweep: ($F_0 \pm \Delta F$)	Continuously adjustable from 0 to ± 5% of band about any center frequency (F_0).
Sweep Rate:	Continuously adjustable from 10 milliseconds to 100 seconds per sweep.
Sweep Trigger:	Four modes; EXTERNAL, FREE RUN, LINE and MANUAL (single sweep). In EXTERNAL mode a 10 microsecond or longer pulse, greater than 2 volts amplitude, triggers sweep. In LINE mode, sweep is triggered by the input line voltage. In MANUAL mode, sweep is triggered by front panel push button.
Sweep Output:	In SINGLE FREQUENCY mode, F_0 output is a zero to 15 volt signal varying in direct proportion to F_0. In swept operation mode, $F_1 \rightarrow F_2$, sawtooth wave begins at zero volts and increases linearly to 15 volts regardless of start and stop frequency settings. Output impedance is approximately 10 K ohms. In SINGLE FREQUENCY mode F_1 output is zero; F_2 output is 15 volts.
Blanking Output:	A+50volt signal is available during sweep retrace. Output impedance is approximately 10 K ohms.

Amplitude Modulation:	Three modes; EXTERNAL, OFF and internally generated SQUARE WAVE. Square wave symmetry within 5%. Rise time; less than 10 microseconds. Repetition rate; 800 to 1200 cps continuously adjustable. Externally applied signal of -15 volts reduces amplitude to zero. Rise and fall time; 10 microseconds. Input impedance is approximately 10 K ohms.
Frequency Modulation:	Externally applied signal of 1.5 volts, peak to peak, produces a 10% deviation of full frequency range. Positive going voltage increases frequency. FM can be applied during all modes of operation. Response; dc to 10 kc. Input impedance; 15 K ohms.
Metering:	Backward wave oscillator helix or collector current, balance and power set.
Power Input:	105 to 125 volts, or 210 to 250 volts, 50/400 cps. approximately 150 VA for models with permanent magnet backward wave oscillator tubes. 105 to 125 volts, or 210 to 250 volts, 60 cps approximately 550 VA for models with solenoid focused backward wave oscillator tubes.
Dimensions:	See Figure 1-1
Weight:	Approximately 60 pounds for non-solenoid models. Approximately 75 pounds for solenoid models.

1.2 DESCRIPTION

The ALFRED 630 Series Sweep Signal Generator is a general purpose wide band signal source. The unit utilizes a voltage tuned backward wave oscillator tube powered by low drift, low ripple, precisely regulated power supplies.

The output frequency can be varied proportionally by an external signal or linearly with time over intervals from 0.01 to 100 seconds by an internal sawtooth generator or manually adjusted to any frequency in the band. The swept rf output can be either single or recurrent. Single sweep can be triggered by a panel push button or an external signal. Recurrent sweep can be synchronized to the internal power line frequency, left to free run or triggered by an external signal.

For X-axis drive of oscilloscopes or recorders a positive going sweep voltage, proportional to frequency, is available at the SWEEP OUTPUT jack. Two calibrating voltages are available for setting up recorders. Peak voltage is 15 volts. During sweep retrace, a +50 volt pulse is available at the BLANKING OUTPUT jack for oscilloscope blanking or recorder pen control. A front panel control selects rf ON or OFF during sweep retrace.

Three electronically generated frequency marker pips are provided. They are short, triangular, negative pulses which modulate the rf and may be used for calibration purposes. Pulse width is less than 0.05% of the total frequency range and amplitude is adjusted by a front panel control. The calibrated dial provides clear presentation of markers, sweep start and sweep end frequencies giving a total of five calibrated frequency points during $F_1 \rightarrow F_2$ swept operation.

By front panel selection the rf signal may be amplitude modulated by either an internally generated square wave or by an external source. The square wave is continuously adjustable from 800 to 1200 cps. An externally applied negative signal is dc coupled and circuit response permits pulse rise and fall times of better than 10 microseconds.

FM modulation is available in all modes of operation. The input is dc coupled and response is 1% of the band per 0.1 millisecond.

Leveling of the output is accomplished by a closed loop circuit. Dual barretters are used to sample and compare the rf power to a highly stable reference. The difference, or error voltage, is applied to the backward wave oscillator to continuously correct any variations in output power. In the 630D model, a 0 to 60 db variable attenuator, calibrated in dbm, provides a constant and predetermined power level during all modes of operation. In the 630A model (no attenuator) adjusting the power-set meter to red line provides a constant, resettable, absolute power level.

The backward wave oscillator tube does not require rf adjustment, is encapsulated for protection and is easily replaced. A front panel meter monitors backward wave oscillator tube currents. Protective circuits reduce the likelihood of damage to the tube.

SECTION 2 - OPERATING INSTRUCTIONS

2.1 FRONT PANEL CONTROLS

FREQUENCY CONTROLS: Located to the right of the calibrated dial are three frequency controls; F_1 , F_0 , and F_2. They are used in conjunction with the three frequency indicators and the calibrated dial to set the desired frequencies.

2. MARKER CONTROLS: Below the three frequency controls are two marker controls; M_1 and M_2. They are used in conjunction with the two marker indicators and the calibrated dial to set the desired marker frequencies. In the $F_1 \rightarrow F_2$ mode, F_0 is also a marker.

3. FREQUENCY MODE SELECTOR - RETRACE CONTROL

a. FREQUENCY MODE SELECTOR

OFF: When in this position the backward wave oscillator is biased off and no rf appears at the output. In single frequency operation, the OFF position is used to zero external meters and establish a zero power reference. If the instrument is to be left on but in a standby condition, the FREQUENCY mode selector should be in the OFF position.

F_0: In this position the output of the generator is a single frequency determined by the F_0 indicator. For control of the X-axis of X-Y recorders, a voltage proportional to the F_0 frequency is provided at the SWEEP OUTPUT jack. The F_0 mode can be used as a pre-set frequency for spot frequency checks in conjunction with F_1 and F_2.

F_1: In this position the output of the generator is a single frequency determined by the F_1 indicator. A calibration voltage is provided at the SWEEP OUTPUT jack and can be used to set the start point on oscilloscopes and recorders for use in the SWEEP mode. The F_1 mode can be used as a pre-set frequency for spot frequency checks in conjunction with F_0 and F_2.

F_2: In this position the output of the generator is a single frequency determined by the F_2 indicator. A calibration voltage is provided at the SWEEP OUTPUT jack and can be used to set the end point on oscilloscopes and recorders for use in the SWEEP mode. The F_2 mode can be used as a pre-set frequency for spot frequency checks in conjunction with F_0 and F_1.

$F_1 \rightarrow F_2$: In this position the output of the generator is a swept frequency beginning at the F_1 frequency indicator and ending at the F_2 frequency indicator. The sweep frequency range (from F_1 to F_2) can be varied from 100% to 2% of the frequency band of the generator. When in this mode marker pips are provided at the F_0 , M_1 and M_2 frequency settings. In this position, a sweep voltage of 15 volts amplitude appears at the SWEEP OUTPUT jack.

$F_0 \pm \Delta F$: In this position the output of the generator is a swept frequency which is symmetrical about the F_0 frequency. ΔF can be varied from 5% of the band to zero. The $F_0 \pm \Delta F$ mode can be used to examine small perturbations, seen when using the $F_1 \rightarrow F_2$ mode, by setting the F_0 marker pip at the perturbation frequency and changing the mode from $F_1 \rightarrow F_2$ to $F_0 \pm \Delta F$. When in this mode marker pips are provided at the M_1 and M_2 frequency settings. In this position a sweep voltage, of 15 volts amplitude, appears at the SWEEP OUTPUT jack.

b. RETRACE CONTROL

Concentric with the FREQUENCY mode select-

or. This control is operative only in the SWEEP modes. In the OFF position, the rf is off during retrace.

4. METER CONTROL: This control is located directly beneath the meter.

BACKWARD WAVE OSCILLATOR CURRENT (BWO I): In this position backward wave oscillator currents can be measured on the meter. By selecting the appropriate position of the rear panel switch (HELIX/DELAY LINE or COLLECTOR) tube current can be read. With backward wave oscillator tubes that have both a helix and collector, the full scale reading is 20 ma when S913 is in the COLLECTOR position. In the HELIX/DELAY LINE position, full scale reading is 5 ma. With tubes that have an inter-digital delay line or helix but no collector, the full scale reading is 50 ma when S913 is in the HELIX/DELAY LINE position. The COLLECTOR position is inoperative because collector currents do not exist.

BALANCE: In this position the backward wave oscillator is biased off enabling the barretters to be balanced by the front panel screwdriver adjustment. For correct adjustment the meter pointer is set to red line.

RF LEVELED: In this position the rf output is maintained constant across the frequency band. In the 630D types the magnitude of the output is determined by the setting of the attenuator, which is calibrated in dbm, when the meter is set to red line by the concentric POWER SET control.

RF UNLEVELED: In this position the rf output (for 630D types) is the maximum the tube can supply minus the sum of the insertion loss and the setting of the attenuator. In the 630A types the output is the maximum the tube can supply.

5. POWER SET CONTROL: Concentric with the METER control. In the 630D types the POWER SET control sets the power level so the attenuator correctly indicates power in dbm and in the 630A types it sets the specified power level. Both are accomplished by adjusting the control so the meter pointer is exactly on red line when the METER control is in the RF LEVELED position.

6. ATTENUATOR CONTROL: (630D type only). The ATTENUATOR control, located at the lower right corner of the scale, adjusts the amount of attenuation in the output circuit. When the output is leveled the scale is calibrated in dbm. When the output is unleveled the scale provides a means for adjusting relative power in db. Scale readings should always be taken directly below the solid black line.

7. MODULATION CONTROL: This control is located below the METER control.

AM OFF: When in this position, the rf output is unmodulated.

AM EXTERNAL: When in this position a negative signal, applied to the AM INPUT jack, will decrease the rf output.

SQUARE WAVE: In this position, the rf output is modulated by an internally generated square wave whose frequency can be varied between 800 and 1200 cycles per second by the SQUARE WAVE FREQUENCY control which is concentric with the MODULATION control.

8. SWEEP TIME CONTROL: This control sets the time to sweep from the start frequency point to the end frequency while in the $F_1 \rightarrow F_2$ sweep mode and the time to sweep from $F_0 - \Delta F$ to $F_0 + \Delta F$ in the $F_0 \pm \Delta F$ sweep mode. There are

four major settings: .01, 0.1, 1.0 and 10 seconds, with continuous intermediate settings adjustable up to 100 seconds by the concentric knob. When the concentric knob is full clockwise, the sweep time is calibrated to the value indicated by the SWEEP TIME control: .01, 0.1, 1.0 or 10 seconds.

9. SWEEP TRIGGER CONTROL

EXTERNAL: When in this position a positive signal applied to the EXTERNAL INPUT jack will trigger the sweep.

FREE RUN: In this position the sweep is triggered immediately upon the completion of a cycle.

LINE: In this position the sweep trigger is synchronized with the input line frequency or a sub-multiple of the line frequency, depending upon the setting of the sweep time control.

MANUAL: In this position the sweep is triggered by pressing the concentric button.

10. ΔF AMPLITUDE CONTROL: This control varies the width of the symmetrical sweep about F_0 when the FREQUENCY mode selector is in the $F_0 \pm \Delta F$ mode. In full clockwise position, the width is at least $\pm$ 5% of the frequency band.

11. MARKER AMPLITUDE CONTROL: This control sets the amplitude of the marker pulses that are visible in the swept rf output. The type of circuit used results in a pulse whose width is also reduced as the amplitude is reduced.

12. HIGH VOLTAGE RESET: If, for some reason, the helix current limitation of the backward wave oscillator is exceeded, the high voltage will automatically turn off. If correct adjustments are made and the reset button is pressed, high voltage will be restored.

2.2 INITIAL TURN-ON

2.2.1 POWER REQUIREMENTS

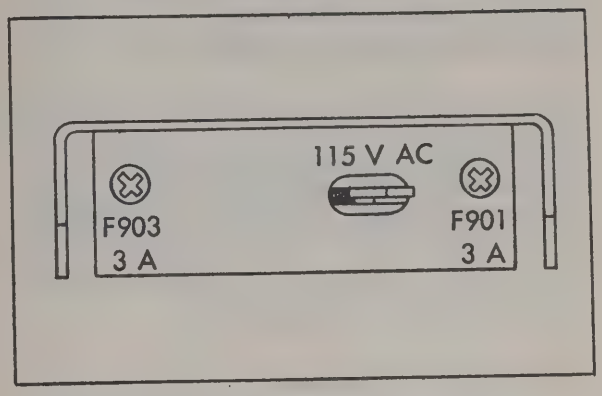


Figure 2-2. AC Line Switch.

The unit is normally connected at the factory for operation at 105 to 125 volts and 50 to 400 cycles ac (115 volts nominal). However, provisions are made for easy conversion to operation at 210 to 250 volts, 50 to 400 cycles ac (230 volts nominal).

With the top cover removed locate the power switch plate labeled 115 VAC. (See Figure 2-2) By removing and reversing this plate the switch can be moved to the left. Replace the plate with 230 VAC showing. Replace the 8 ampere main fuse (in back of instrument) with a 6 ampere fuse.

2.2.2 INITIAL TURN-ON PROCEDURES

Prior to regular operation of the unit, the following test should be performed.

1. Set the METER control to BWO I.
2. Set FREQUENCY mode selector to SINGLE; F_0.
3. Set FREQUENCY indicator, F_0 , to the low end of the scale.

4. Set MODULATION control to AM OFF.

5. Move the METER switch (S913) at rear of the instrument to HELIX/DELAY LINE.

6. Turn POWER switch to ON.

NOTE: Time delay relays used in the Model 630 Series delay high voltage turn on for approximately 60 seconds after the POWER switch is turned ON to allow a brief warm up period for the backward wave oscillator filament. If the ac power is off for only an instant, the normal 60 second delay will occur before high voltage returns.

7. When high voltage appears, measure the helix current on the front panel meter. At this setting the full scale reading is 5 ma, and the helix current should be less than the trip out current specified in Chart #1, Section 5. Move METER switch on rear of instrument to COLLECTOR. Observe the collector current on the meter. The full scale reading is 20 ma and any value between 5 and 15 ma indicates correct collector current.

8. With tubes that have delay lines (no collector) the METER switch should be set to HELIX/DELAY LINE. With these tubes the full scale reading is 50 ma and the value should be between 10 and 40 ma. The collector or delay line current can vary from instrument to instrument and no definite value is therefore established.

If the above procedure checks out, the unit is ready for operation.

2.3 OPERATING PROCEDURE

Turn POWER switch to ON. Set the METER control to BALANCE and adjust the meter to read red line by using the front panel screw driver adjust.

NOTE: After approximately ten minutes of operation, check for red line drift. If drift is noted, the BALANCE should be readjusted.

After high voltage appears, the instrument is ready for operation. If leveled output is desired, the METER control is set to RF LEVELED and the concentric POWER SET control adjusted so the meter reads red line. This establishes the power level. In the 630D types the attenuator setting correctly indicates power in dbm.

If unleveled output is desired, the METER control is set to RF UNLEVELED. In the 630D types the attenuator now provides a means for adjusting the power and is calibrated in db. In the 630A types the output is the maximum the backward wave oscillator tube can supply.

CAUTION: When using the RF UNLEVELED position, the rf power output can be as great as 200 milliwatts.

For wide sweep operation the FREQUENCY mode selector is set to SWEEP; $F_1 \rightarrow F_2$ and the F_1 and F_2 FREQUENCY indicators are set to the desired start and end frequency points. The SWEEP; TIME and TRIGGER controls can be adjusted to the desired time and trigger conditions.

For narrow sweep operation the FREQUENCY mode selector is set to SWEEP; $F_0 \pm \Delta F$ and the F_0 FREQUENCY indicator is used to set the desired frequency.

The ΔF AMPLITUDE control can be adjusted to the sweep width desired. A maximum value of at least $\pm$ 5% of the frequency band of the instrument is available.

Example: Frequency band of instrument = 2 to 4 Gc
Band Coverage = 2 Gc

5% of 2 Gc = 100 Mc (maximum ΔF)

When sweeping in either the wide or narrow sweep modes, markers are available by turning up the MARKER AMPLITUDE control. In the $F_1 \rightarrow F_2$ mode, there are three markers available whose frequencies are set by the F_0, M_1 and M_2 control knobs. In the $F_0 \pm \Delta F$ mode two markers are available; M_1 and M_2.

During either wide or narrow sweep there is provided, at the SWEEP OUTPUT jack a sawtooth waveform whose amplitude is +15 volts peak. Also provided, at the BLANKING OUTPUT jack, is a +50 volt pulse which occurs during retrace.

For single frequency operation the FREQUENCY mode selector can be set to SINGLE; F_0, F_1 or F_2 with the desired frequency set by the F_0, F_1, or F_2 control knobs. For manual sweep, the FREQUENCY mode selector is set to SINGLE F_0 and the F_0 control knob is used to sweep the frequency manually. During manual sweep a dc voltage, proportional to F_0 frequency, is provided at the SWEEP OUTPUT jack.

2.4 REMOTE FREQUENCY OPERATION

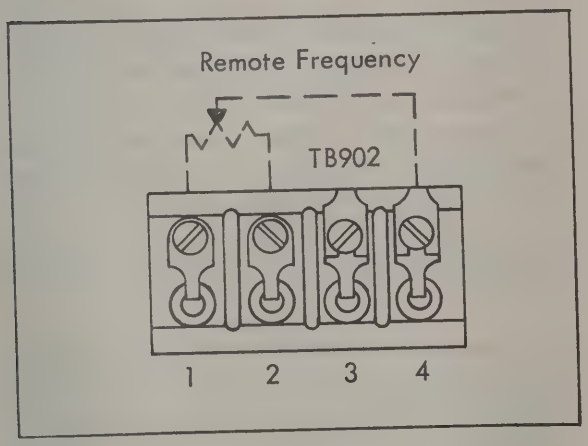


Figure 2-3. Remote Frequency Control.

If it is desired to control the F_0 FREQUENCY at some distance from the instrument, terminal block TB902 is provided at the rear of the instrument for this purpose. See Figure 2-3. Remove the jumpers at TB902-3 and -4 and insert a 1 K Ωpotentiometer as indicated by the dotted lines.

NOTE: Shielded wires should be used to connect the external 1 K Ωpotentiometer to the terminal. (A shielded three wire cable is satisfactory.)

SECTION 3 - CIRCUIT DESCRIPTION

3.1 GENERAL

The high frequency rf energy, produced by the unit, is generated by a backward wave oscillator tube. The tube is controlled by highly stable power supplies. Through proper voltage control the backward wave oscillator provides a means of producing either a variable frequency (sweep mode) or a stable frequency (single mode). See Block Diagram, Figure 3-12.

The secondary reference voltages of the unit are the +15 and -15 volt supplies. The frequency of oscillation of the backward wave oscillator tube is primarily determined by the voltage between its cathode and helix. By referencing the cathode to helix potential to the + and -15 volt power supplies, a highly stable frequency is obtained.

To permit the unit to sweep from a start to an end frequency, a sweep generator is provided whose output is amplified by the cathode supply of the backward wave oscillator tube and causes the frequency to change linearly with time.

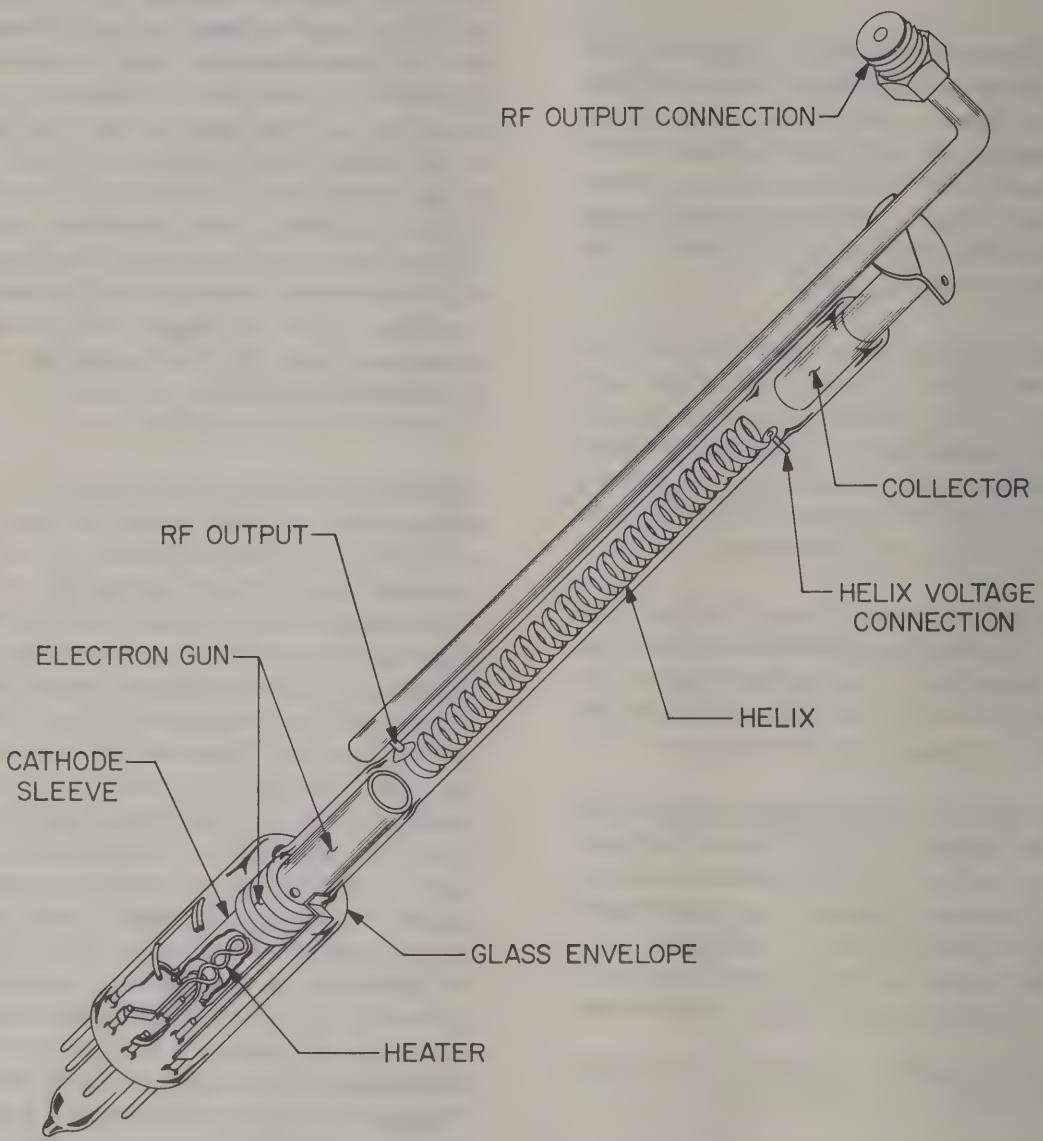
Auxiliary circuits provide modulation capabilities so that the amplitude of oscillation of the backward wave oscillator tube may be controlled. Two means are provided; a leveler circuit which maintains the amplitude constant, independent of its frequency of operation, and an on-off type modulator which provides amplitude modulation.

3.2 THE BACKWARD WAVE OSCILLATOR TUBE

The backward wave oscillator tube consists of an electron gun, a slow wave structure and a collector at the far end of the slow wave structure. The rf output of the tube is produced by the interaction between the electron beam and the electromagnetic field of a microwave signal developed on the slow wave structure. See Figure 3-1.

The electron gun contains a heated cathode and two or more aperture disc type control electrodes which help form the beam and control beam density. In a helix backward wave oscillator, it is desirable to have a hollow cylindrical electron beam since only the electrons that pass adjacent to the helix are fully effective in delivering energy to the wave. Electrons near the middle of the beam consume anode power but contribute little or nothing to the energy interchange that produces the backward wave oscillations. Surrounding the tube is a magnet which produces a strong axial field. This field focuses the electrons in the beam and allows movement only in the direction of the axis of the tube.

Oscillations, and hence the rf wave, begin in the backward wave oscillator in much the same manner as they begin in other oscillators. Noise waves are established on the helix from the shot noise coupled from the electron beam and from thermal energy developed at the input end of the tube. Waves are produced which travel in both directions in the helix, i. e., from gun to collector and from collector to gun. Since the desired wave in a backward wave oscillator must travel from the collector to the gun end, attenuators are placed in the tube which eliminate the forward moving waves. Amplification of the wave is produced by the interaction of the electrons in the beam and the electromagnetic field of the wave. To obtain this interaction, the electron beam must be at some critical velocity which is achieved by applying a dc voltage to the helix. Because the electromagnetic field is alternating, electrons in the beam are subjected to either an accelerating or decelerating field. Thus, the electrons entering the helix experience velocity modulation with a tendency for a bunch of electrons to be formed as they move through the helix. The critical areas of interaction are the spaces between the helix turns because the axial electric field is strong between helix turns and weak under the turns.



BACKWARD WAVE OSCILLATOR TUBE
FIGURE 3-1

To explain the bunching process, let us examine a group of electrons as they travel from the gun to the collector end of the tube. Within this group there will be one electron, e, which corresponds to the zero point of the alternating axial field and is therefore unaffected by the signal on the helix. See Figure 3-2A. This electron experiences no acceleration from the electromagnetic field. However, an electron just to the left of e, e', encounters a positive axial field and is accelerated thus tending to catch up with e. Similarly, electron e", which is just to the right side of e, encounters a negative or decelerating field and so slows down and tends to be overtaken by electron e. The electrons centered about e are thus velocity modulated. This situation is repeated over and over again as the electrons centered about the reference electron pass one space after another. Now, by choosing the electron velocity so that at the collector end of the tube the phase difference between the wave and bunches in the beam is approximately one half cycle, the electron bunches will encounter relatively strong decelerating fields as they cross the spaces. Thus, the kinetic energy of the electrons is transferred to the backward wave. The amplitude of the backward wave builds up as it progresses toward the gun end of the tube because it passes more and more bunches from which it receives energy. At the same time, the alternating component of the beam current, i. e., the bunching becomes greater as the electrons progress toward the collector. See Figure 3-2B.

The operating frequency range of a particular backward wave oscillator tube is primarily determined by the dimensions of the slow wave structure. Since the most commonly used slow wave structure is a helix the following discussion will be based upon this type of tube.

It is well known that a slow wave structure will propagate a particular range of frequencies at constant axial velocity (the non-dispersive region) and above that range, the velocity of propagation increases with frequency (the dispersive region). The backward wave oscillator operates in the dispersive region and it will oscillate at the frequency for which the beam velocity is very nearly equal to the axial velocity of propagation. Figure 3-2C shows the variation of propagation velocity with frequency for a particular helix while Figure 3-2D shows how the beam velocity varies with the helix to cathode voltage.

From these figures it can be seen why the backward wave oscillator can be voltage tuned. By changing the helix to cathode voltage, the beam velocity changes and the frequency for which the velocity of propagation and the velocity of the beam are in synchronism changes. The helix dimensions, primarily diameter and pitch, are chosen so that the tuning voltages required for a particular frequency range are reasonable (usually about 200 to 2000 volts).

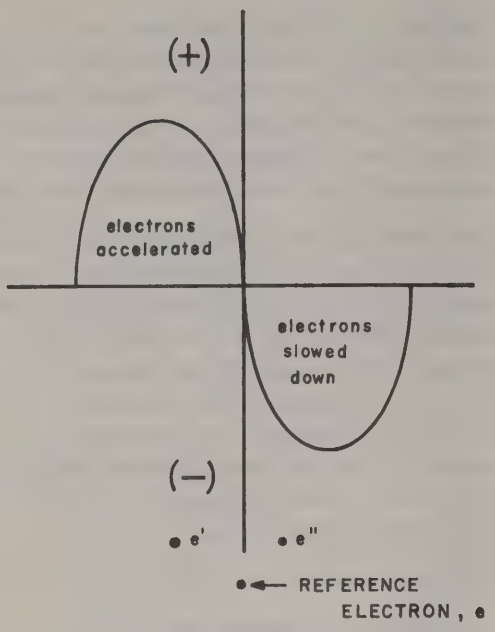
3.3 +15 AND -15 VOLT POWER SUPPLIES

The +15 and -15 volt power supplies provide the reference voltages for the unit. The primary reference for the unit is A2CR1, a 1N823A temperature compensated zener diode. This diode is used as the reference for the -15 volt supply. See Figure 3-3.

The -15 volt supply consists of a two stage differential amplifier, a driver, and a series regulator transistor. The amplifier consists of an input differential stage A2Q8; A2Q6 and A2Q7 the second differential stage and A2Q5 the driver for the series regulator transistor Q904.

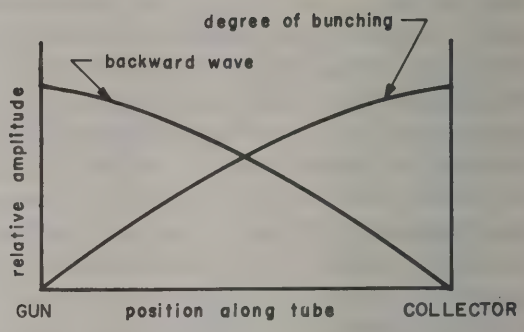
The use of metal film resistors in all critical circuits and matched transistors in the input stage at A2Q8, minimizes noise and drift in this supply. As in all closed loop feedback systems, tight control of phase response must be maintained. This is accomplished in this circuit by A2C5 and A2R34 located at the collector of A2Q6.

The -15 volts applied to A2R10 is used as the reference for the +15 volt supply. To control the output of the +15 volt supply, a two stage differential amplifier, a driver, and a series regulator transistor are also used. The amplifier consists of an input differential stage A2Q4; A2Q2 and A2Q3 the second stage and A2Q1 the driver stage. Q903 is the series regulator. The main phase re-



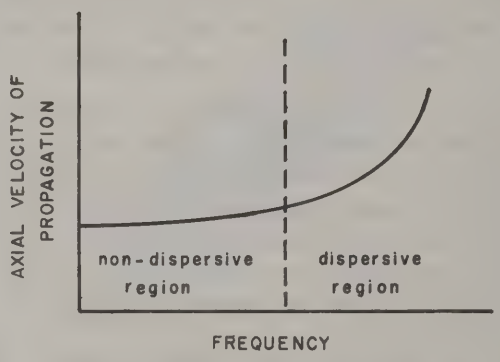
ELECTRON DISTRIBUTION

(A)



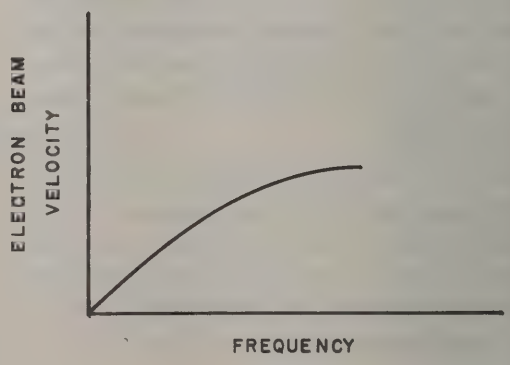
RELATIVE AMPLITUDE VS. POSITION ALONG TUBE

(B)



AXIAL VELOCITY OF PROPAGATION VS. FREQUENCY

(C)



ELECTRON BEAM VELOCITY VS. FREQUENCY

(D)

Figure 3-2. Backward Wave Oscillator Tube Characteristics.

sponse control for the +15 volt supply is A2C2 located across the collector of A2Q4.

The -15 volt supply is adjusted by A2R18 and the +15 volt supply is adjusted by A2R9.

3.4 +100 AND -50 VOLT POWER SUPPLIES

In addition to the +15 and -15 volt supplies, there are two other low voltage sources; the +100 and -50 volt power supplies. The +100 volt supply consists of a single stage differential amplifier A2Q9 and A2Q10 which drive the series regulator transistor Q901. A neon bulb, DS903 protects Q901 during turn-on. The +100 volt supply uses the -15 volt supply as a reference. See Figure 3-4.

The -50 volt supply consists of a two stage amplifier and a series regulator. The amplifier consists of A2Q12 the input stage and A2Q11 the driver. Q905 is the series transistor. The +15 volt supply is the reference for this supply. Phase response is controlled in the second stage by means of A2C10 and A2R37.

Diode A2CR2 is for temperature compensation and diode A2CR3 prevents transients from damaging A2Q12.

3.5 CATHODE SUPPLY

The cathode supply for the backward wave oscillator is an operational amplifier using both tubes and transistors. See Figure 3-5. It consists of a summing junction and a transistorized operational amplifier which controls the grids of the series regulator tubes V901, V902 and V903, located in the rear of the instrument. The summing junction and the operational amplifier are located on PC Board 100. The summing junction is at the base of Q101. A portion of the dc output is fed into the input of the summing junction, through high impedance emitter followers Q109 and Q110, forming a complete feedback system whose output can range from 150 to 2500 volts. The high impedance path makes it unnecessary to use high power resistors, thus minimizing power dissipation and hence thermal drift. Two diodes, CR101 and CR102, are used to compensate for any temperature deviations which occur in the emitter followers. Also in the feedback network is a non-linear, voltage sensitive attenuator consisting of a diode shaping network located on PC Board 900. It causes the output of the cathode supply to become non-linear with respect to its input and thus compensates for the non-linear tuning curve of the backward wave oscillator. Hence, the output frequency is directly proportional to the input voltage of the amplifier. For single frequency operation a voltage directly proportional to the frequency dial indicator position is applied to the amplifier input. During $F_1 \rightarrow F_2$ swept operation a linearly varying voltage, supplied by the sweep generator, is applied to the amplifier input. When in the $F_0 \pm \Delta F$ sweep mode a linearly varying voltage, supplied by the sweep generator, starts at $F_0 - \Delta F$ and sweeps to $F_0 + \Delta F$. This sweep voltage is applied to the amplifier input. The external modulation input is also connected to the amplifier input. A 1.5 volt signal will change the frequency by 10% of the band.

Tubes are used as the control elements for the high voltage supply because of their ability to withstand the high voltage required for the cathode of the backward wave oscillator. Transistors were chosen for the preamplifier because of their immunity to microphonics and low power requirements.

3.6 ANODE SUPPLY

The gun structure of all backward wave oscillators contains an anode which collimates the electron beam before it is accelerated to helix potential. The anode operates at an elevated potential with respect to the cathode and may vary from 50 to 200 volts depending upon the tube type. See Figure 3-6. Supply regulation is by a shunt regulator circuit consisting of one vacuum tube, which serves as the shunt regulator element, and three transistors. The transistor amplifier drives the shunt regulator tube and is located on PC Board 800. A reference voltage is furnished by the 70 volt grid bias supply. The anode voltage is adjusted by means of R806, the ANODE VOLTAGE ADJUST potentiometer.

3.7 FILAMENT SUPPLY

The filament supply is a regulated, variable, dc supply using a series regulator transistor and a two stage transistor amplifier. See Figure 3-6. The regulator amplifier, consisting of Q801 and Q802, is located on the elevated supplies' board, PC800. A zener diode, CR801, is the supply reference. The output voltage may be adjusted by means of R824, the backward wave oscillator HEATER VOLTAGE ADJUST, located on PC Board 800.

3.8 SWEEP GENERATOR

The sweep generator is located on PC Board 300 and PC Board 700. The four basic circuits on PC Board 300 are the Miller integrator consisting of Q304-Q307, the trigger circuitry consisting of Q308-Q311, a gating multivibrator consisting of Q301-Q302, and a retrace hold-off circuit consisting of Q312-Q314. See Figure 3-7.

The basic part of the sweep generator is the Miller integrator, a capacitive feedback dc amplifier which integrates its input voltage producing a linearly increasing output. This linear output creates a ramp which is used as the sweep in the instrument. The feedback capacitors for the Miller integrator are C701-C704, located on PC Board 700. The slope of the ramp output of Q307 is determined by the feedback capacitors and resistors R945 and R946.

Prior to the initiation of the sweep, Q301 in the multivibrator is off causing a positive voltage to be fed to the base of Q314. This causes the output of the retrace hold-off circuit Q312, to be positive which places a positive voltage on the base of Q304, the input to the Miller integrator circuit. This holds the output of the Miller integrator circuit, the collector of Q307, at approximately zero volts. A positive trigger applied to the base of Q309, through resistor R319, causes the Schmitt trigger, Q310 and Q311, to switch. The resulting negative spike on the collector of Q311 is fed to the base of Q302 in the multivibrator, through S906, causing the multivibrator to change states. Q302 is now off, or in the non-conducting state, while Q301 is on, or in the conducting state. This causes positive voltage to be removed from the base of both Q314 and Q304. The Miller integrator now generates a ramp function determined by the setting of switch S903, which selects the feedback capacitor and by the adjustment of R946, the SWEEP TIME multiplier control. When the ramp output of Q307 reaches 40 volts, CR302 becomes forward biased placing a positive voltage on the base of Q302, causing the multivibrator to change states. A positive voltage is again applied to the Miller integrator input, through the retrace hold-off circuit, causing the feedback capacitor to rapidly discharge. The Miller integrator output returns to zero volts. Thus, the sweep completes one cycle of operation and is ready for another. The sweep output from Q307 is channeled to the frequency controls through emitter follower Q705. The output of Q705 is also connected to emitter follower Q704, which in turn is connected to the SWEEP OUTPUT jack, J915.

In addition to the ramp output, this circuitry also provides a blanking voltage generated at the collector of amplifier Q303. The input to Q303 is taken from the collector of Q302 in the gating multivibrator circuit. Q303 amplifies the multivibrator output producing a +50 volt pulse which occurs during retrace and can be used for recorder pen lift or for oscilloscope blanking.

3.9 SWEEP TRIGGER MODES

The Model 630 provides four means of initiating or triggering a sweep. The choice is provided by the front panel SWEEP TRIGGER control whose four positions are FREE RUN, EXTERNAL, LINE and MANUAL. In the FREE RUN position the sweep is self-triggered. When the sweep returns to zero volts CR301 conducts, causing the sweep gate multivibrator to flip into the opposite condition, immediately retriggering the sweep cycle. In the EXTERNAL mode, transistors Q310 and Q311 form a Schmitt trigger which takes any arbitrary input waveform and transforms it into a step function. The step function is differentiated and the resultant spike is fed to CR301 to trigger the sweep. In the LINE mode a 6.3 volt ac rms voltage, at the line frequency, is supplied to the

Schmitt trigger thus synchronizing the sweep rate to the power line frequency. In the MANUAL mode the push button switch connects the Schmitt trigger to the +15 volt supply and allows just one trigger each time the button is depressed.

3.10 GRID SUPPLY

The 70 volt grid supply furnishes power to the grid driver amplifier. See Figure 3-6. It is shunt regulated and uses a two stage transistor differential amplifier to drive the shunt regulator transistor, Q803. A zener diode reference, CR802, is used to determine the supply output. Most of the components of this supply are located on PC Board 800.

3.11 MARKER CIRCUIT

See Figure 3-8.

The marker circuit provides wavemeter like pips to indicate preset frequencies set by the F_0 , M_1 or M_2 FREQUENCY control knobs. The markers are electronically generated from the sweep. A voltage is summed into the markers by the marker adjusting potentiometers M_1 , M_2 or F_0. The signal applied to the input of the cathode supply is also applied to the marker input. The marker has a condition which depends upon the backward wave oscillator beam voltage or the oscillating frequency of the backward wave oscillator as related to its input voltage. Hence, the same total current is summed into the helix supply and the action of the markers is identical in character to the helix supply. Thus, the marker generated is directly related to the frequency of oscillation of the backward wave oscillator tube.

A marker will appear when the input current corresponding to the frequency of oscillation is balanced by the current from the marker potentiometer. The first three stages of the marker circuit are amplifiers. The fourth stage is a high gain differential amplifier which is activated only when the input current is at the balance point (the point at which the frequency of oscillation is precisely that indicated by the marker). At this point, the voltage on R420 goes from a maximum to a minimum and the voltage on R422 goes from a minimum to a maximum. CR403 and CR404 from a diode adder. The most negative voltage applied to either diode will control the output. Hence, the output is first connected to R422 and then R420. Consequently, the amplifier has a waveform which is triangular in shape. The markers are positioned by potentiometers R932 (F_0), R927 (M_1) and R926 (M_2).

All three marker circuits operate in exactly the same manner. The marker signals, from the three marker circuits, are added together with a dc voltage, which controls their amplitude and the sum is applied to emitter follower Q419, and then to the amplitude modulation circuits.

3.12 AMPLITUDE MODULATION AND LEVELING CIRCUITRY

See Figures 3-9 and 3-10.

To control the amplitude of oscillation of the backward wave oscillator, a negative voltage must be applied between its grid and cathode. The operating potential of the cathode is anywhere between 150 and 2500 volts depending upon the tube used and the frequency of oscillation. A coupling scheme is required to transmit a controlling voltage which can be referenced to the cathode. The coupling scheme is a transfer oscillator whose output passes through high voltage capacitors to a detector circuit, which in turn controls the grid of the backward wave oscillator. Thus, any modulation applied to the backward wave oscillator is first reproduced in the transfer oscillator and again on the grid of the backward wave oscillator. (The microwave amplifier is thereby modulated by means of the modulation circuitry, which is near ground potential, through the transfer oscillator and then to the grid of the backward wave oscillator.)

The power level of the backward wave oscillator tube is controlled by means of a feedback leveler. Rf energy from the output of the tube is sampled by means of a directional coupler and then fed into a bolometer mount. The bolometer consists of a pair of barretters, one of which is sensitive to the rf energy. Rf energy incident upon the barretter causes a change in temperature which changes its resistance. A constant current is applied to the barretter converting the resistance change to a voltage change. A reference barretter, in the same mount, is not exposed to the rf energy, but is subject to the same ambient temperature variations because it is thermally in contact but electrically isolated from the other barretter. The output of the barretters is connected to the input of a differential amplifier which response to rf variations but not to ambient temperature changes. When the reference barretter is independently heated by a high frequency signal, supplied by a controllable oscillator, a voltage difference will appear at the input of the differential amplifier. This voltage is then amplified and applied, through a feedback system, to the transfer oscillator, resulting in an increase in the amplitude of oscillation of the tube and more energy is supplied to the rf sensitive barretter. Since the open loop gain of the system is large the rf microwave energy is controlled to match the energy supplied to the reference barretter. Hence, any modulation applied to the reference barretter must also be reproduced in the rf due to the feedback action of the leveler. Consequently, the modulation is actually applied to the controllable oscillator which provides power to the reference barretter. The controllable oscillator is feedback controlled and operates at approximately 10 megacycles.

Modulation of the controllable oscillator can be accomplished by either an external source or an internally generated square wave. The square wave voltage is produced by two transistors acting as a multivibrator. The frequency of the square wave is varied by a front panel control over a range of 800 to 1200 cps. There are two other controlling inputs to the oscillator; the input from the markers so they will appear on the rf and an input from the retrace blanking circuit to cut off the oscillator during retrace.

It is also possible to operate the Model 630 in the unleveled mode. In this condition the circuits are unbalanced in such a way that zero bias is applied to the grid of the backward wave oscillator tube and maximum power output is produced.

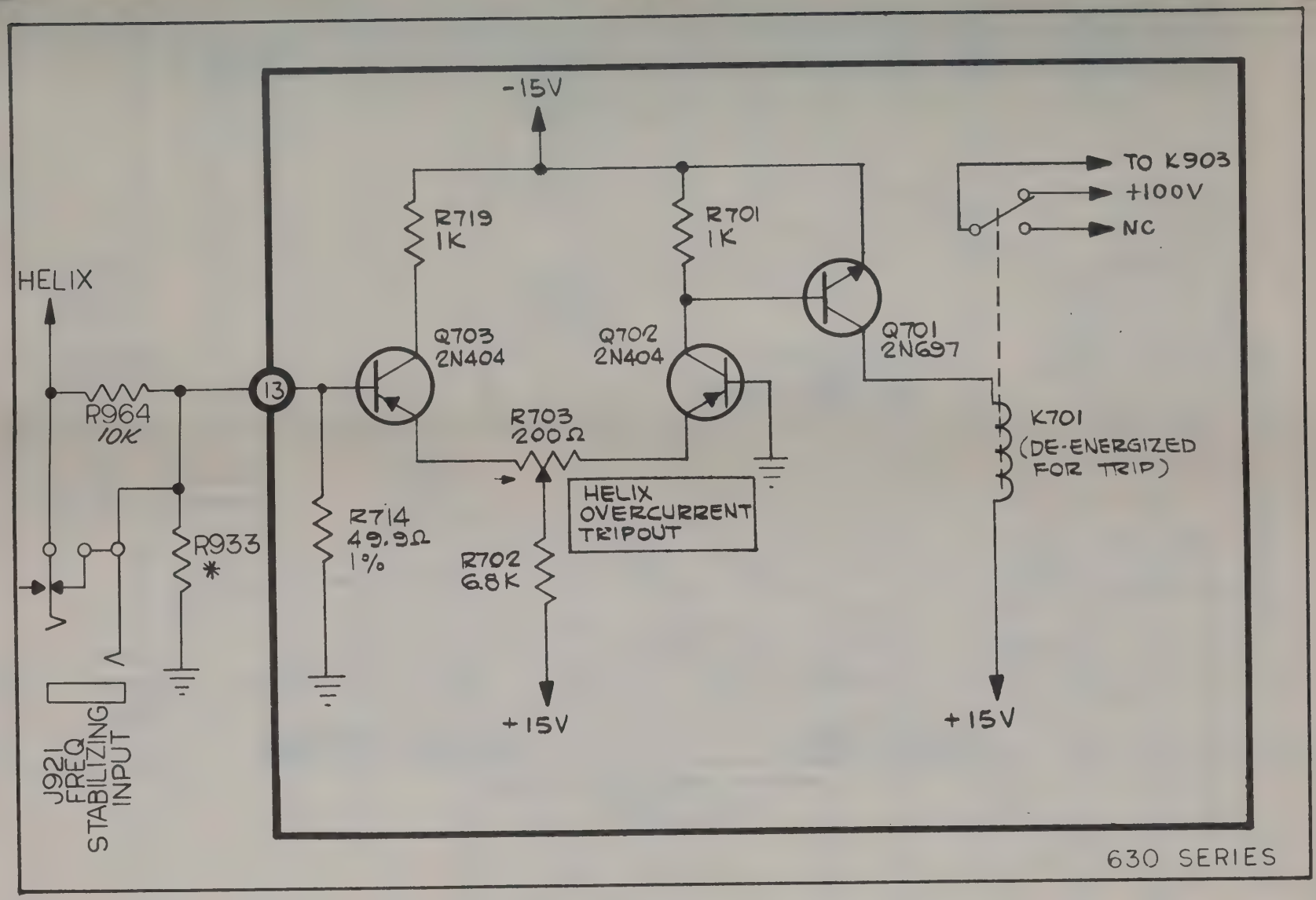
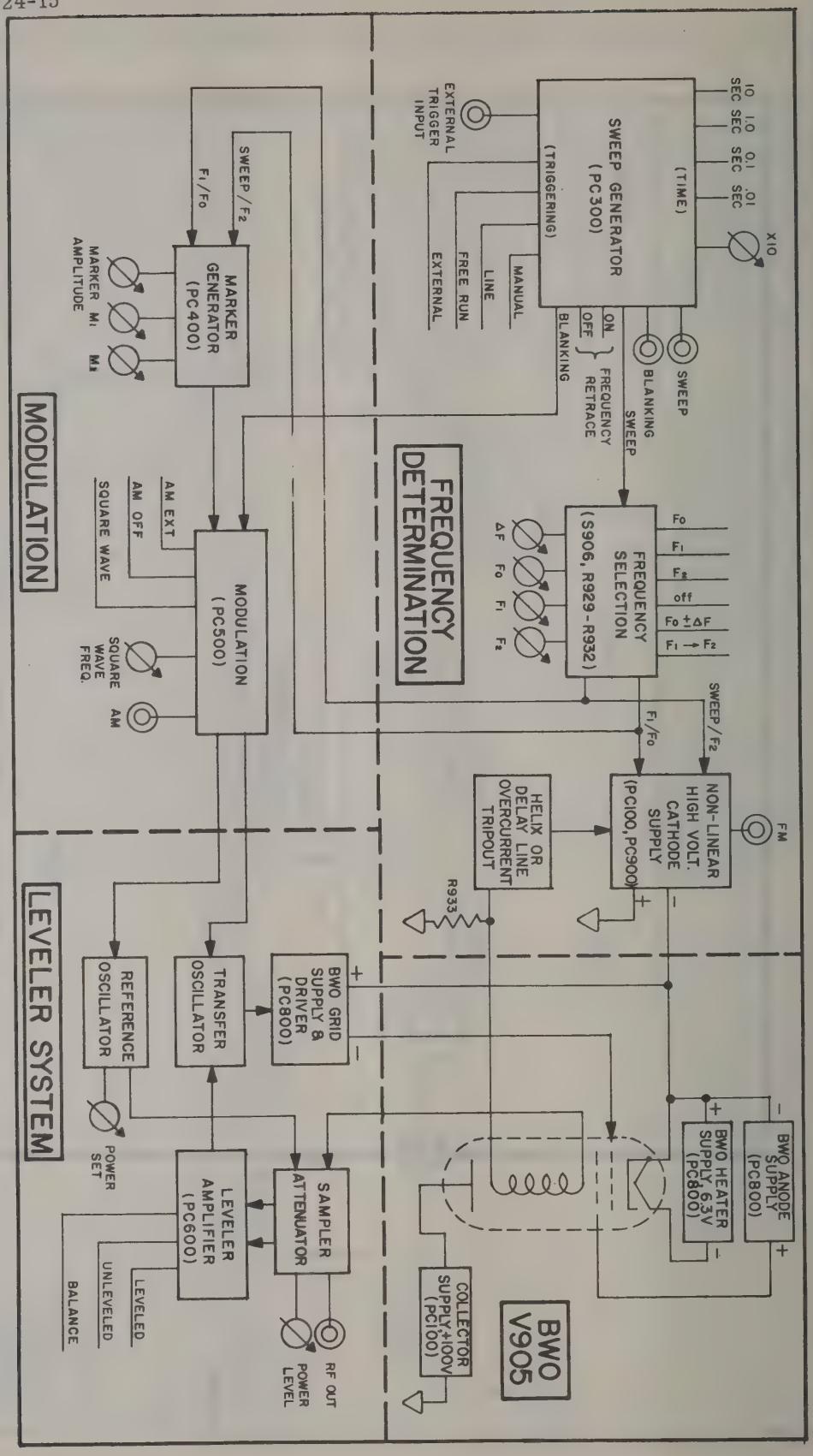


Figure 3-11. Helix Overcurrent-PC-700.



MODEL 630 SWEEP SIGNAL GENERATOR
BLOCK DIAGRAM
FIGURE 3-12

SECTION 4 - MAINTENANCE

CAUTION: High voltages exist in this instrument. Observe caution when calibrating or performing maintenance on the instrument. When the back or top cover plates are removed, the high voltage interlock turns OFF the HIGH VOLTAGE.

4.1 TROUBLE SHOOTING

If trouble is encountered, the following procedures may help isolate the cause.

NOTE: Before attempting to trouble shoot the instrument, make sure that an apparent trouble is actually due to a malfunction within the instrument and not to improper control settings or external causes.

4.1.1 GENERAL

1. Check all fuses. Replace with type 3AB, 250 volt and current value specified.

2. If power can be applied without blowing fuses, check the four low voltage power supplies; +15, -15, +100 and -50 and the elevated supplies; anode, grid and filament.

NOTE: A floating voltmeter must be used to check the elevated supplies.

If a power supply is at fault, the cause may be due to a defective transistor or tube, or one of the circuits using the supply may be excessively loading it due to a defective or grounded component.

4.1.2 NO HIGH VOLTAGE WITH HIGH VOLTAGE INDICATOR LIGHT OFF

1. Check to see if K901 (-9, 8) to (-3, 4) closes after 60 seconds.

2. Check the thermal time delay relay. Check for 6.3 volts at XK901-1, -6.

3. If K902 does not close, check the +100 volt supply.

4. See if the jumper at TB901-1, -2 is in place.

5. Check to see if K903 is de-energized. If not, check the HELIX TRIP-OUT circuit as follows;

   a. Set METER control to BWO I

   b. Set rear switch, S913 to HELIX/DELAY LINE

   c. Set FREQUENCY mode selector to SINGLE; F_0

   d. POWER switch to ON

After approximately 60 seconds, the high voltage should momentarily appear. Note the meter reading while the high voltage is present. If it is equal to or greater than the value given in Chart #1, Section 5, the backward wave oscillator tube and its associated voltages should be checked. If the relay trips out at a meter reading which is appreciably lower than the value indicated, then the setting of the trip out circuit should be checked according to the procedures of the Overcurrent Trip-out Adjustment, Paragraph 4.4.3.

4.1.3 NO HIGH VOLTAGE WITH HIGH VOLTAGE INDICATOR LIGHT ON

1. Check the output of T902 (CAUTION: HIGH VOLTAGE - 1100 volts rms at terminals 7 and 9).

2. Check the rectifier and the filter circuit.

3. Check series tubes V901, V902 and V903.

4. Trouble shoot the cathode supply board, J900.

4.1.4 NO RF UNDER ANY CONDITION

1. With the high voltage OFF, check the backward wave oscillator heater voltage between (+) TP7 and (-) TP8. Value should be approximately 6.3 volts. If not, try to adjust to 6.3 by using R824 (see Figure 4-4).

   If value cannot be obtained, trouble shoot the filament supply.

2. With the unit OFF, disconnect P920 from J920. Measure the resistance at Pins C and B of P920. The value should be less than 20 ohms. The specific value will depend upon the tube. If the circuit shows open, the filament of the backward wave oscillator tube is open and the tube should be replaced. If the filament is not open, reconnect P920 and J920.

3. With the MODULATION control at AM OFF, the FREQUENCY mode selector at SINGLE; F_0, the METER control at BWO I and the F_0 FREQUENCY control to 0 on the logging scale; measure the cathode voltage between (+) TP0 and (-) TP7.

4. With the HIGH VOLTAGE ON, measure the anode voltage between (+) TP5 and (-) TP7 (CAUTION: HIGH VOLTAGE).

5. Measure the voltage between (-) TP0 and (+) TP11. The value should be between 8 and 12 volts. If not, trouble shoot the modulation circuit (PC500) and the switching in the modulation circuit (located on the rear of the front panel).

6. Measure the voltage between (+) TP9 and (-) TP10 (CAUTION: HIGH VOLTAGE). The value should be between 4 and 8 volts. If not, trouble shoot the transfer oscillator circuit.

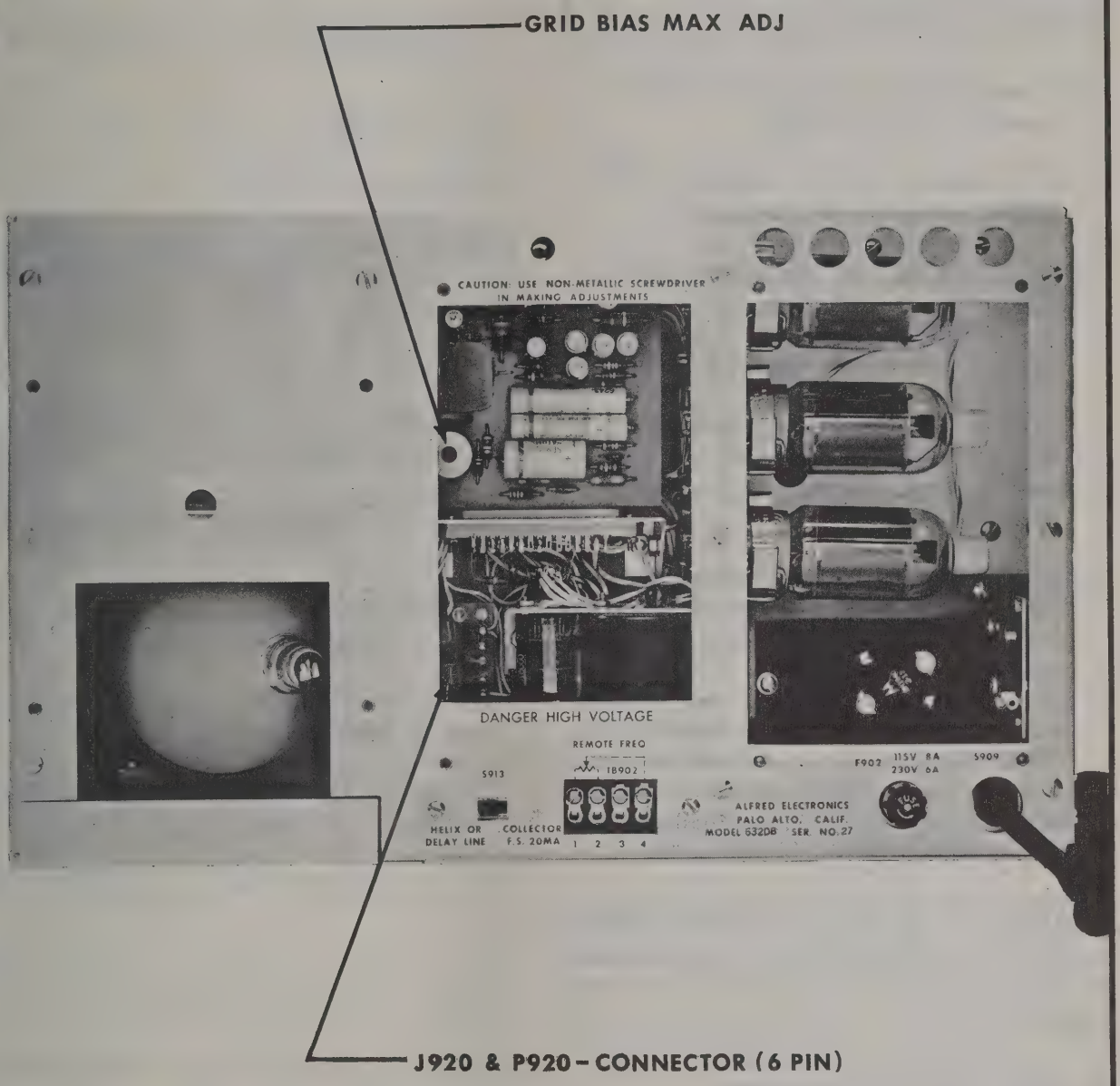
7. With METER control at BWO I, FREQUENCY mode selector to SINGLE; F_0, and the MODULATION control at AM OFF, measure the grid voltage between (+) TP7 and (-) TP6. The value should be less than 2 volts. If not, check the grid supply and the grid driver stage on PC Board 800 (Elevated Supply).

8. If all supplies and voltages check out and there is no indication of helix or collector current on the meter, replace the backward wave oscillator.

4.1.5 RF NOT LEVELED OR NO RF OUTPUT WHEN METER CONTROL IS IN LEVELED POSITION

NOTE: When the METER control is in the LEVELED position and the power of the unit varies less than the specified value for your instrument (see Specifications, para 1-1) as indicated on a suitable power meter over the full frequency range, the rf is leveled. If the power varies more than the specified value, perform the following:

1. Set METER control to BALANCE. Check to see if red line can be obtained by using the front panel screwdriver adjust. If not, check the resistance of the barretters. See Figure 4-6. The value should be between 100 and



REAR VIEW

FIGURE 4-1

200 ohms, but not open circuit.

CAUTION: Use ohmmeter whose current does not exceed 10 milliamperes.

2. If barretters are good, trouble shoot the leveler circuit, PC 600.

3. If the leveler circuit checks out, set the METER control to RF LEVELED.

   The FREQUENCY mode selector to SINGLE; F_0.

   The MODULATION control to AM OFF.

   Check to see if the concentric POWER SET control can give a meter reading of 1 to at least 7. If not, trouble shoot the reference oscillator, PC 500.

4. If leveling occurs over most of the band but not over all of the band, check the rf output in the UNLEVELED condition while sweeping the entire frequency range. If the output, in any part of the band, is less than the minimum specified for your instrument in the LEVELED condition (see specifications, para 1-1) the anode voltage can be increased until the required power is available by adjusting R806 (ANODE ADJUST).

CAUTION: Do not advance the ANODE ADJUST beyond the point where collector or helix current is greater than the value specified by the tube manufacturer.

4.1.6 UNIT UNABLE TO SWEEP

1. Set FREQUENCY mode selector to SWEEP; $F_1 \rightarrow F_2$.

2. Set SWEEP; TIME control to .01 seconds, calibrated.

3. Set SWEEP; TRIGGER control to FREE RUN.

4. Check diodes and transistors on PC Board 300.

5. Check the waveforms and compare to those of Figure 4-2.

4.2 TEST POINTS

See Figures 4-3 and 4-4

NOTE: TP0 through TP4 located left side of instrument. TP5 through TP10 located top rear insulated board.

TP0 chassis ground.

TP0 to TP1, +100 volts (low voltage supply; 97 volts to 103 volts).

TP0 to TP2, +15 volts (low voltage supply; +15 volts).

TP0 to TP3, -15 volts (low voltage supply; 14.9 volts to 15.1 volts).

TP0 to TP4, -50 volts (low voltage supply; 45 volts to 55 volts).

TP7 to TP5, backward wave oscillator anode voltage.

TP7 to TP6, backward wave oscillator grid.

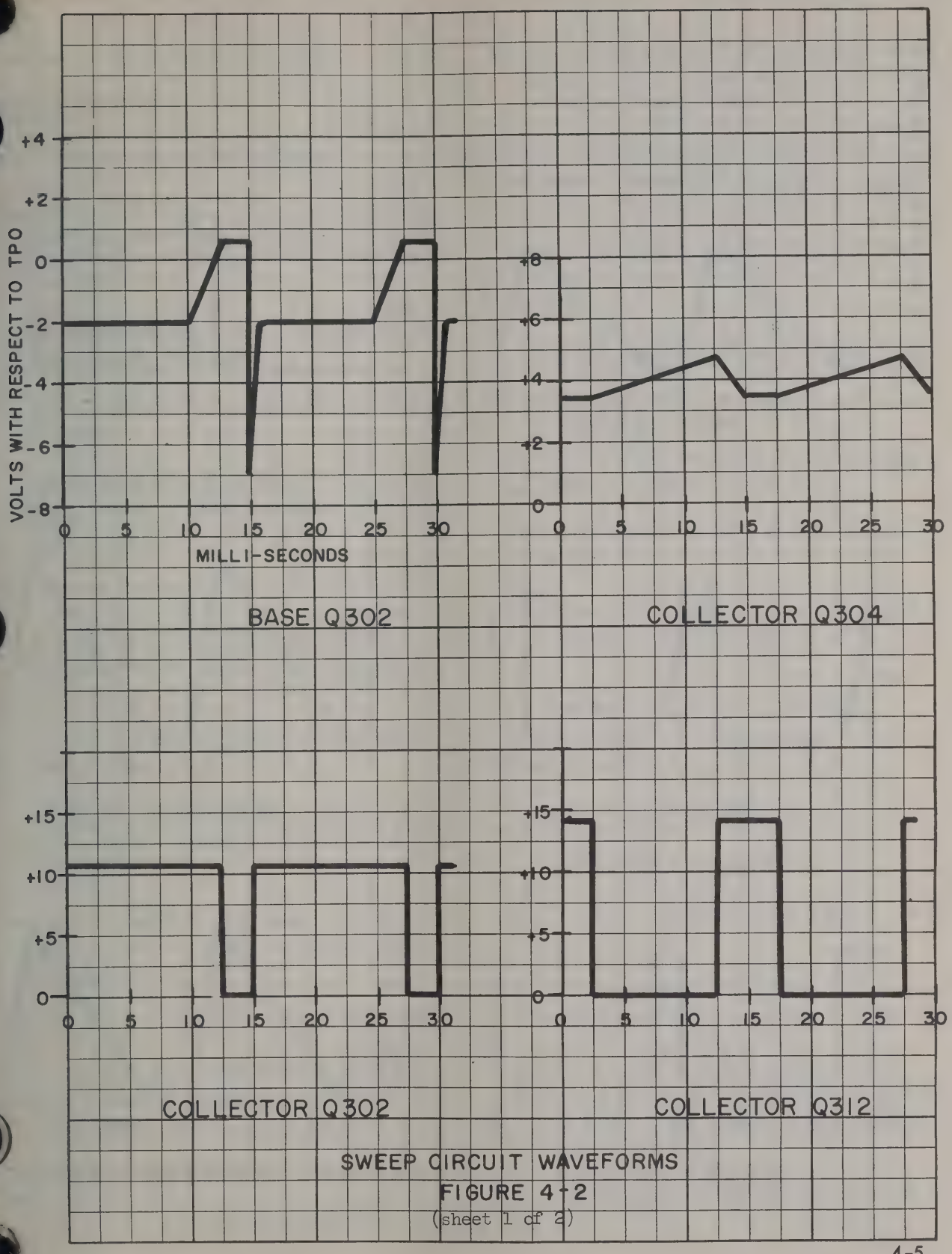
TP7 to TP9, backward wave oscillator grid supply (-60 volts to -70 volts).

TP0 to TP7, backward wave oscillator cathode.

TP7 to TP8, backward wave oscillator heater (6.2 volts to 6.4 volts).

TP10 to TP9, output of transfer oscillator.

TP0 to TP11, input to transfer oscillator. (TP11



SWEEP CIRCUIT WAVEFORMS
FIGURE 4-2
(sheet 1 of 2)

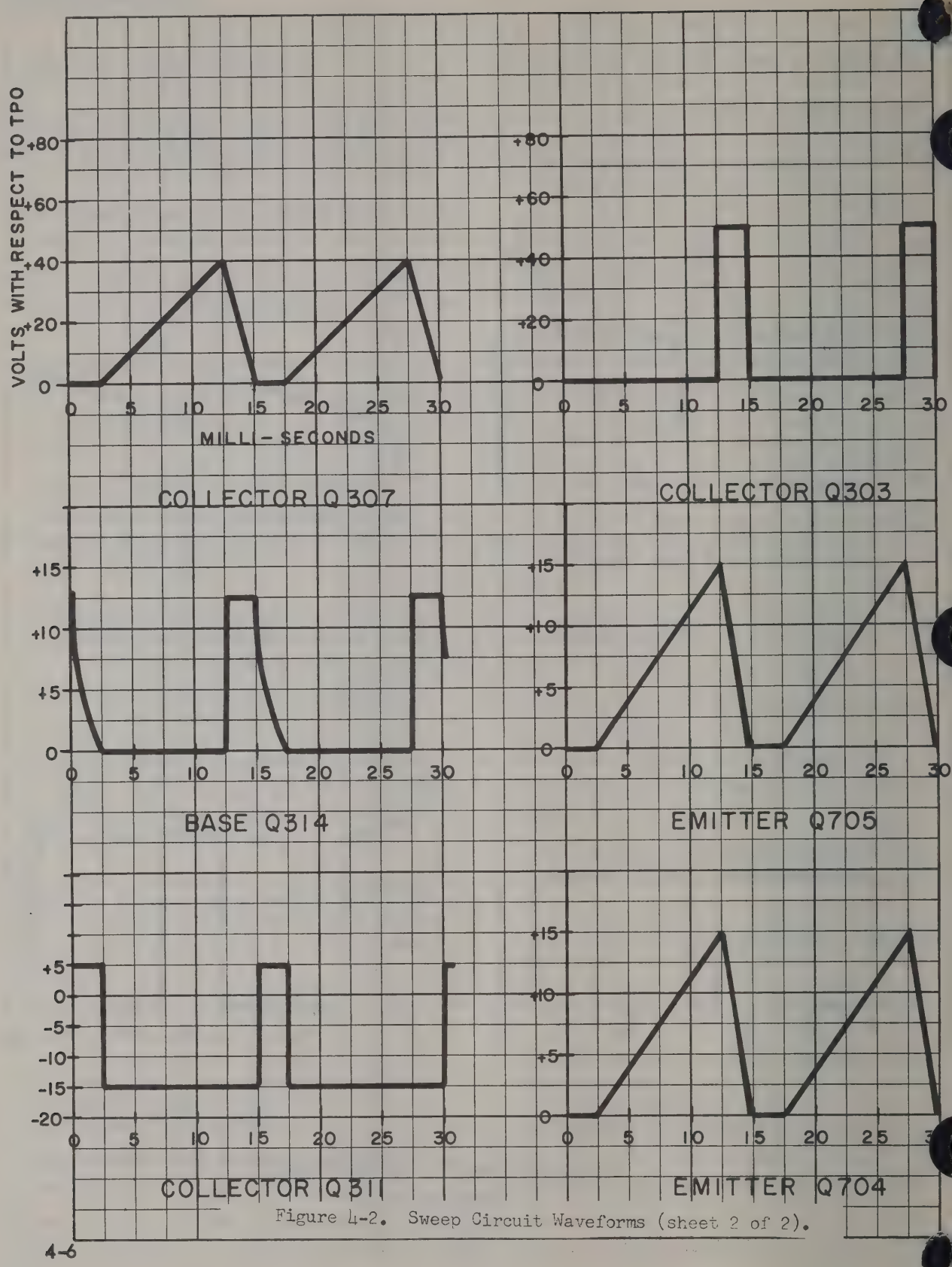


Figure 4-2. Sweep Circuit Waveforms (sheet 2 of 2).

Located on main chassis near C903.

4.3 CALIBRATION

4.3.1 FREQUENCY CALIBRATION

1. Turn POWER switch to ON with an appropriate rf wavemeter, crystal detector and oscilloscope connected to the RF OUTPUT of the unit.
2. Check BALANCE (red line). Then set METER control to RF LEVELED.
3. Set FREQUENCY mode selector to SWEEP; $F_0 \pm \Delta F$.
4. Set F_0 FREQUENCY indicator to the lowest frequency value of the instrument (0 on the logging scale).
5. Set the rf wavemeter to this frequency.
6. Adjust R125 (START FREQUENCY ADJUST) so the wavemeter pip appears in the center of the oscilloscope face. See Figure 4-3.

   NOTE: ΔF AMPLITUDE control should be full on (clockwise).
7. Reduce the ΔF AMPLITUDE control while adjusting R125 so the pip remains in the center.
8. Move F_0 FREQUENCY indicator to the high frequency value of the instrument (100 on logging scale).
9. Set the rf wavemeter to this frequency.
10. Adjust R121 (END FREQUENCY ADJUST) so the wavemeter pip appears in the center of scope face.

NOTE: ΔF AMPLITUDE control should be full on (clockwise).

11. Reduce the ΔF AMPLITUDE control while adjusting R121 so the pip remains in the center of the oscilloscope face.

Repeat Steps 1 through 11 until both ends are on frequency. Repeating the steps is necessary because of the interaction of R125 and R121.

4.3.2 WIDE SWEEP CALIBRATION

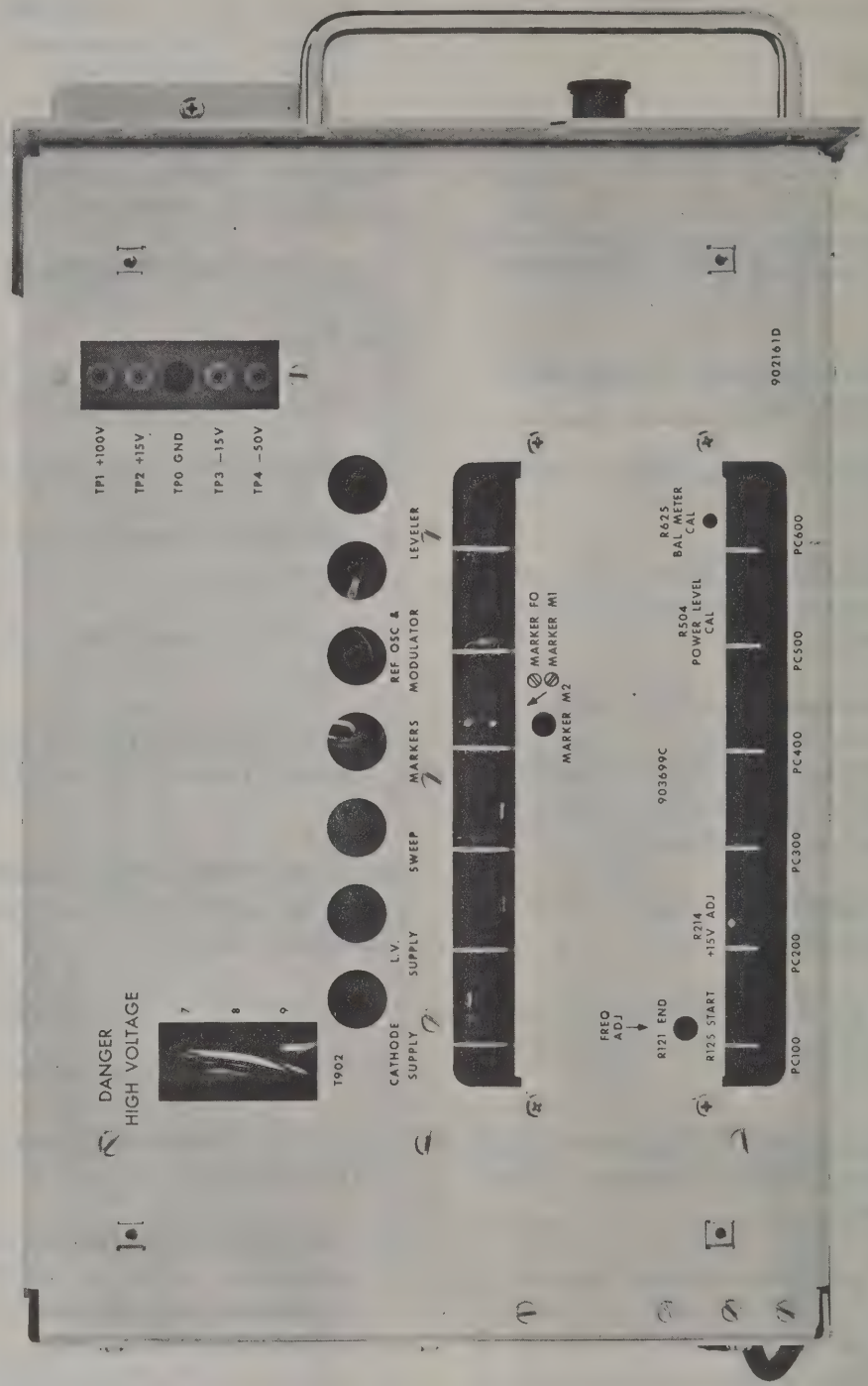
See Figure 4-4

1. FREQUENCY mode selector to SWEEP; $F_1 \rightarrow F_2$
2. FREQUENCY control F_1 to 0 on logging scale.
3. FREQUENCY control F_2 to 100 on logging scale.
4. Adjust frequency meter to frequency of F_2 setting.
5. Adjust R709 until pip is exactly at end of sweep as seen on the oscilloscope.

4.3.3 RF POWER LEVEL CALIBRATION

See Figure 4-3.

1. Remove the left handle side.
2. Turn POWER switch to ON.
3. Connect a suitable rf power meter to the RF OUTPUT jack.
4. Set the POWER LEVEL to +10 dbm using the attenuator control on 630D models. (No modulation and single frequency.)
5. Set the METER control to BALANCE and adjust meter to red line by using the adjacent screw driver adjust.
6. After adjustment, set METER control to RF



LEFT SIDE VIEW

FIGURE 4-3

LEVELED and adjust the power level to red line on the meter by using the concentric POWER SET control.

7. Measure the output power with the rf power meter.

8. Adjust R504 (POWER LEVEL CALIBRATION) until +10 dbm is indicated on the rf power meter while keeping the meter red lined. This will require the operator to continuously adjust the POWER SET control for red line as any adjustment of R504 affects the meter reading.

9. Check the power level over the entire frequency band to see if it is within ± 1/2 db of +10 dbm.

0. Replace the left handle side.

4.3.4 MARKER CALIBRATION

Set METER control to RF LEVELED.

2. Set FREQUENCY mode selector to SWEEP; $F_1 \rightarrow F_2$.

3. Set F_1 FREQUENCY control to 0 on the logging scale.

4. Set F_2 FREQUENCY control to 10 on the logging scale.

5. Set SWEEP; TIME to .1 seconds (calibrated).

6. Set SWEEP; TRIGGER to LINE.

7. Turn MARKER AMPLITUDE up as necessary.

8. Apply the sweep output of the unit to the horizontal deflection input of an oscilloscope.

9. With a suitable frequency meter and crystal detector in series with the output, display the output of the crystal detector on the oscilloscope.

10. Set the M_1 MARKER control to any frequency between 0 and 10 on the logging scale.

11. Set the frequency meter to this frequency.

12. Adjust R432 (MARKER M_1) until the wavemeter pip and the marker pip coincide.

13. Remove M_1 marker pip from the oscilloscope and set the M_2 MARKER control to the frequency of the frequency meter.

14. Adjust R455 (MARKER M_2) until the wavemeter pip and the marker pip coincide.

15. Remove M_2 marker pip from the oscilloscope and set F_0 FREQUENCY control to the frequency of the frequency meter.

16. Adjust R407 (MARKER F_0) until the two pips coincide.

4.4 INTERNAL ADJUSTMENTS

NOTE: Both the top and rear cover plates actuate safety interlock switches that prevent high voltage operation when removed.

4.4.1 +15 VOLT ADJUSTMENT

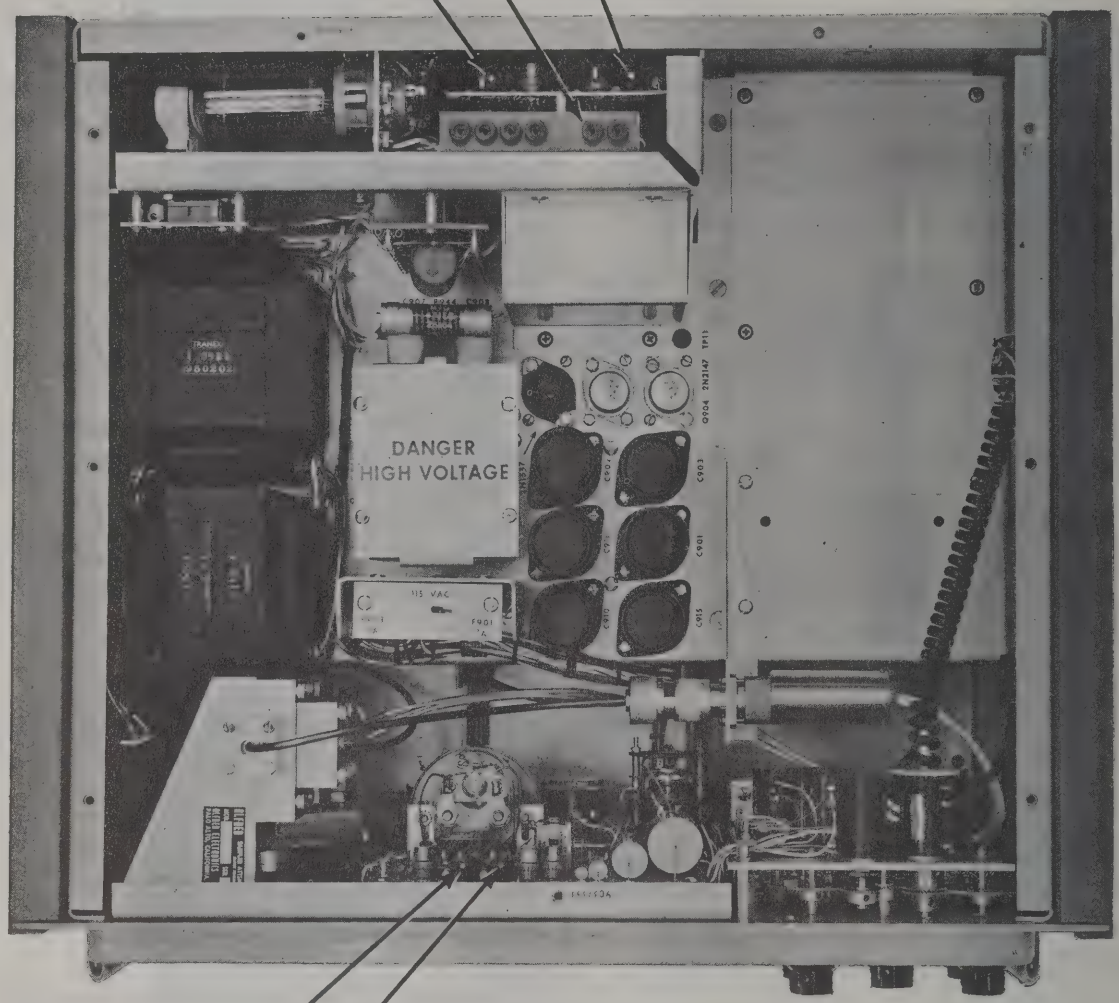
See Figure 4-3

1. Remove the left handle side cover plate.

2. Connect a 0.1% dc voltmeter between TP2 and TP0.

3. Adjust R214 (+15 VOLT ADJUST) for 15.00 volts.

4. This adjustment also affects the -15 volt, +100 and -50 volt supplies but the absolute value of these supplies is not critical.



TOP VIEW

FIGURE 4-4

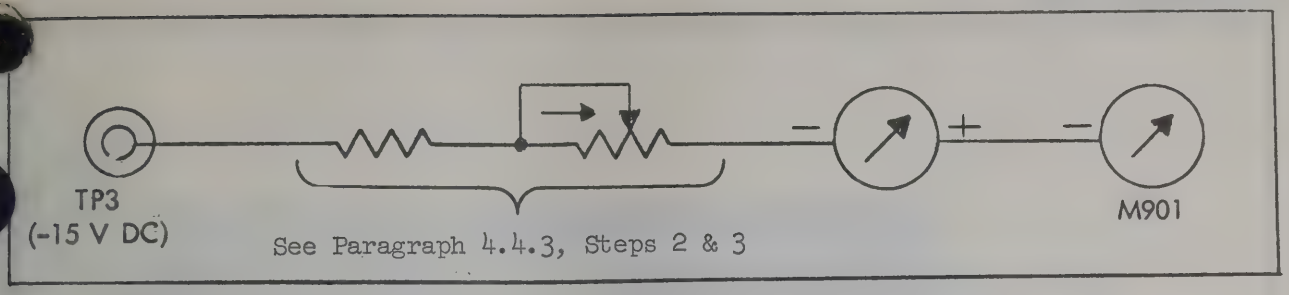


Figure 4-5. Overcurrent Relay Trip-Out Adjust.

5. Replace the left handle side cover plate.

4.4.2 BALANCE METER ADJUSTMENT

See Figure 4-3

1. Remove the left handle side cover plate.
2. Set the F_1 and F_2 FREQUENCY controls to their extreme positions (0 and 100 on the logging scale).
3. Set the FREQUENCY mode selector to SWEEP; $F_1 \rightarrow F_2$ (10 second sweep).
4. Set MODULATION control to SQUARE WAVE.
5. Set METER control to RF LEVELED.
6. Adjust the front panel BALANCE screw driver adjust so that good symmetry, good rise time and minimum overshoot of the square wave is obtained. This adjustment will be a compromise between symmetry, rise time and overshoot.
7. Set METER control to BALANCE.
8. Adjust R625 so that the meter reads red line.
9. Replace left handle side.

4.4.3 OVERCURRENT RELAY TRIP-OUT ADJUSTMENT

See Figure 4-4

Check Chart #1, Section 5 for the proper setting and full scale reading of meter M901 when switch S913 is in HELIX/DELAY LINE setting.

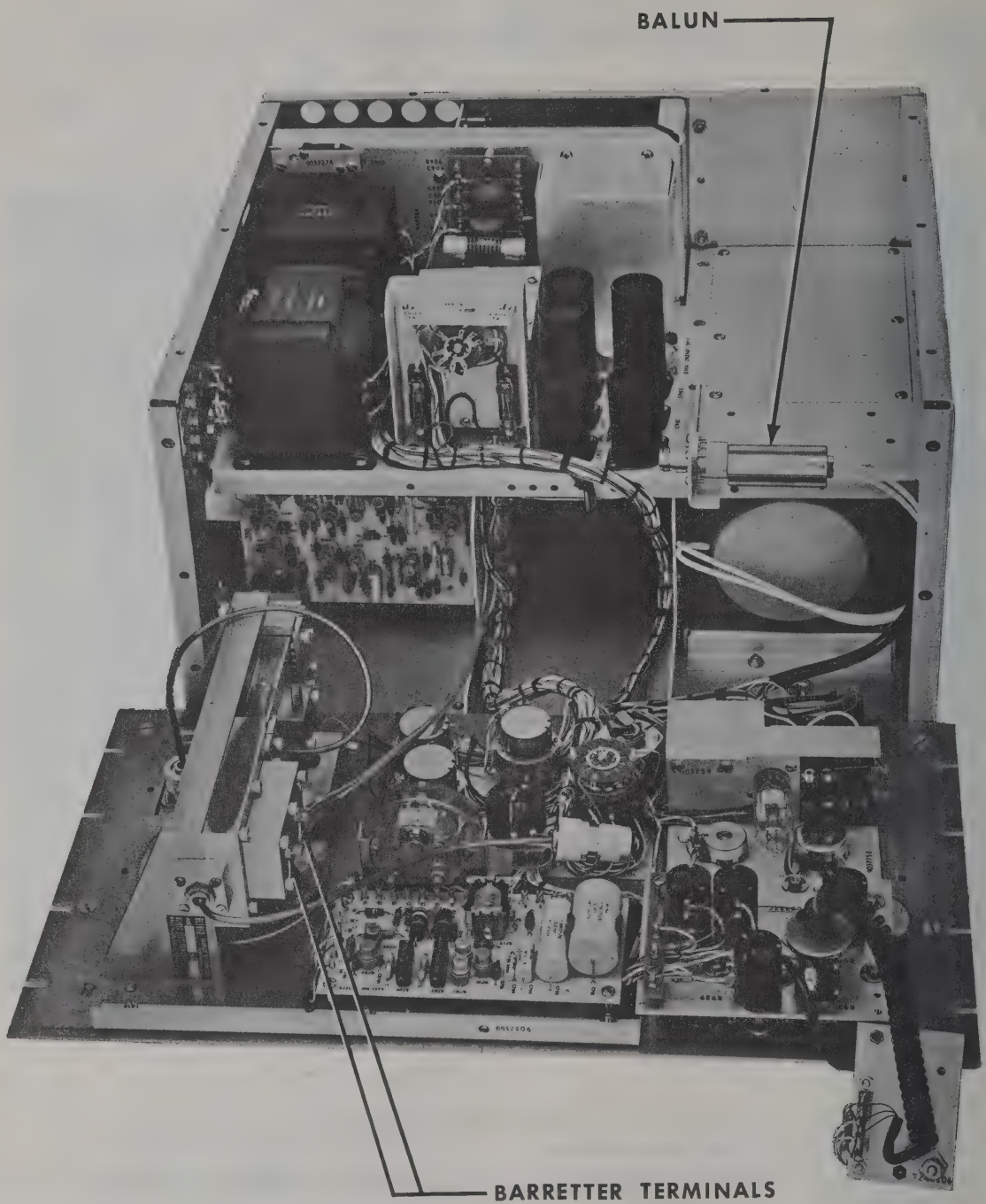
1. Remove the top cover.
2. Connect a 3 K ohm resistor, a 20 K ohm or greater potentiometer and a suitable current meter (5 ma) in series between TP3 (-15 v dc) and the negative terminal of M901. This set-up is for a full scale deflection of 5 ma.
3. For a full scale deflection of 50 ma, connect a 270 ohm resistor a 5 K ohm or greater potentiometer and a suitable current meter (50 ma) between TP3 (-15 v dc) and the negative terminal of M901. See Figure 4-5.
4. Turn POWER switch to ON but leave the HIGH VOLTAGE off by leaving the high voltage interlock open.
5. Set METER control to BWO I.
6. Set rear switch, S913, to HELIX/DELAY LINE.
7. Adjust the potentiometer by starting at a low value of current and gradually increase until the overcurrent relay K701 trips (de-energizes). Check current at which relay tripped. Adjust R703 so the relay trips at the current value indicated.

NOTE: Always proceed from a low current value by adjusting the potentiometer each time the trip-out point is checked.

4.4.4 BACKWARD WAVE OSCILLATOR HEATER ADJUSTMENT

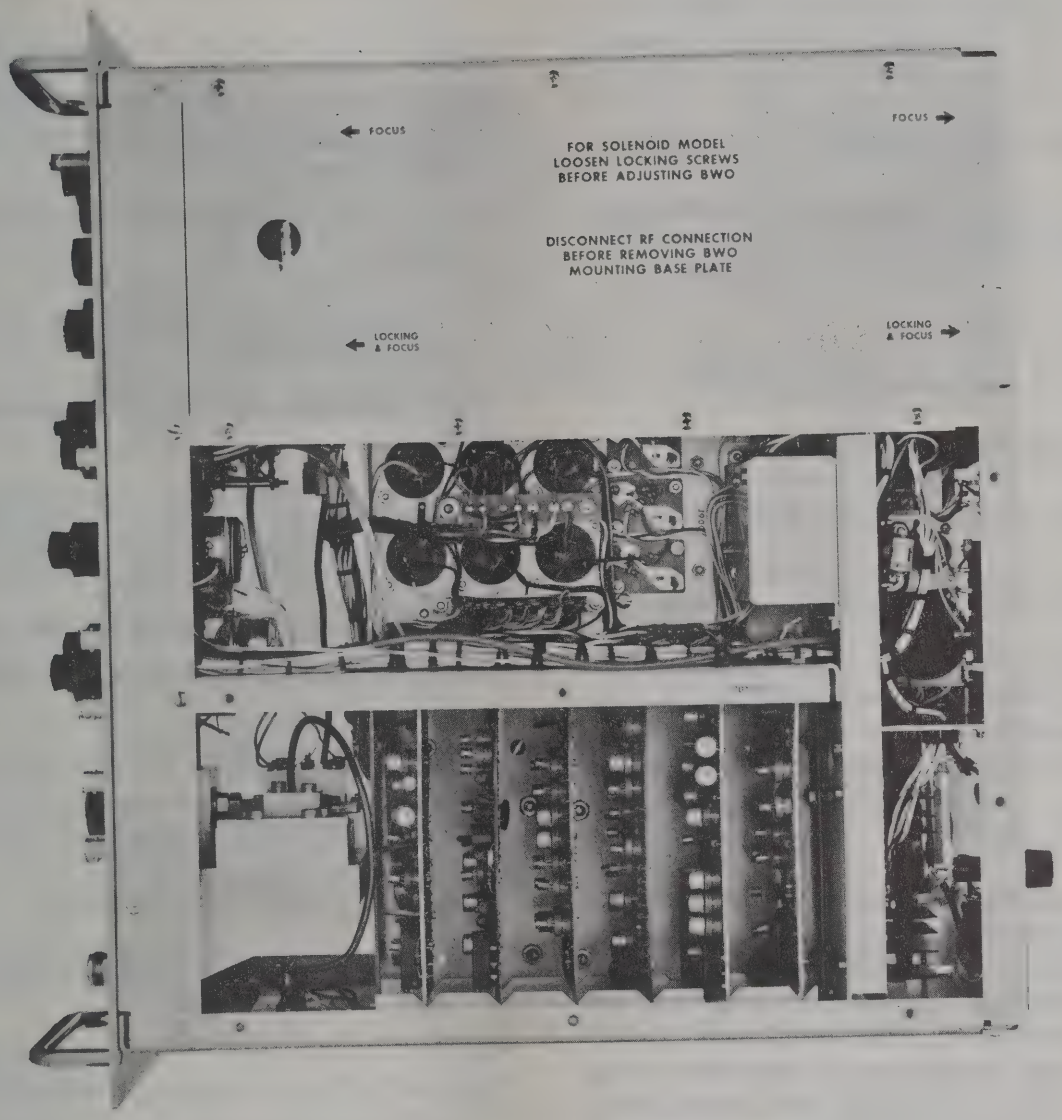
See Figure 4-4

1. Remove the top cover plate.
2. Set FREQUENCY mode selector to OFF.
3. Set F_0 FREQUENCY indicator to 0 on logging scale.
4. Set MODULATION control to AM OFF.
5. Set SWEEP; TRIGGER to FREE RUN.
6. Set SWEEP; TIME to .01 seconds.



FRONT VIEW (PANEL OPENED)

FIGURE 4-6



BOTTOM VIEW
FIGURE 4-7

7. Connect the positive lead of a dc voltmeter to TP7 and the negative lead to TP8.

8. With the instrument ON and the backward wave oscillator connected, adjust R824 to 6.3 volts dc. (This should be done at 115 volt line.)

9. Replace top cover plate.

4.4.5 BACKWARD WAVE OSCILLATOR GRID ADJUSTMENT

See Figure 4-1

Remove the rear cover plate.

1. FREQUENCY mode selector to SWEEP; $F_1 \rightarrow F_2$.

2. MODULATION control to SQUARE WAVE.

3. RETRACE control to OFF.

4. Adjust the GRID BIAS MAX. ADJUST (R818) so that the backward wave oscillator tube does not generate any rf during retrace and during the portion of the square wave where rf is off.

4.5 FRONT PANEL

The front panel may be dropped forward for access to components mounted inside. Remove the five control knobs and the dial mechanism cover. Remove the top cover plate and the right and left handle sides. Remove the coiled cable bracket (two screws). Remove any rf connections using caution. Remove the screws from the periphery of the front panel. The panel may now be turned forward on its face as all wiring comes out the bottom of the panel.

4.6 BACKWARD WAVE OSCILLATOR TUBE REPLACEMENT

See Figure 4-7 and Paragraph 4.8.

To replace the backward wave oscillator tube, remove the top cover plate.

1. Disconnect the rf connection from the tube to the unit.

NOTE: On units with baluns, disconnect the balun bracket from the unit before disconnecting the rf connector. Remove the balun from its bracket prior to Step 2. See Figure 4-6.

2. Turn unit over and remove the bottom cover plate.

3. Disconnect the one and six pin connector (P921 and P920).

NOTE: Some units only have the six pin connector (P920).

4. Remove the seven Phillips head screws from the periphery of the backward wave oscillator mounting base plate. See Figure 4-7.

5. Lift the whole tube assembly (tube and base plate) from the unit by using the finger hole provided.

6. Disconnect the tube from its base plates. Note position and screw hole alignment of old tube to aid in positioning of new tube.

7. Reverse procedure for installation.

4.7 FREQUENCY AND MARKER POTENTIOMETER REPLACEMENT

NOTE: The F_1 and F_2 potentiometers can be removed without dropping the front panel.

4.7.1. REPLACEMENT OF F_1 POTENTIOMETER

1. Remove top cover.

2. Unsolder leads from potentiometer terminals.

3. Rotate F_1 control knob full counterclockwise (CCW) to its lower mechanical stop. It is

important to remember the exact position of the indicator when the stop is reached, as this position must be maintained when the new potentiometer is installed.

4. Loosen both potentiometer shaft gear hub set screws.

CAUTION: Do not disrupt relative position of the F_2 potentiometer shaft gears. Make a pencil mark on the mounting plate and gear and realign before meshing the F_1 gear. If the F_2 gears are moved and not realigned, the mechanical stops will not be oriented and realignment must be performed according to the procedures of 4.7.2, starting with Step 8.

5. Slide gear forward.

6. Remove potentiometer retaining nut and washer. While holding nut, washer and gear, withdraw potentiometer from mounting plate, noting orientation of potentiometer terminals.

7. Insert new potentiometer engaging washer, nut and gear. Tighten retaining nut remembering orientation of potentiometer terminals.

8. Position the F_1 potentiometer shaft full clockwise (CW) as viewed from the shaft end. This can best be accomplished by lightly tightening one gear set screw and while the gear is disengaged, finger turning the shaft full clockwise. Loosen the set screw.

9. Before engaging the gear check to see if the dial indicator is in the exact position as it was before and check to see if the F_2 gear lines up with its pencil mark.

10. Engage the F_1 potentiometer shaft gear and tighten both screws. NOTE: If the indicator is not in the exact position as noted in Step 3, do not position it by turning the F_1 dial cord drum. Instead, disengage the gear and reposition the indicator.

4.7.2 REPLACEMENT OF F_2 POTENTIOMETER

1. Remove the top cover, the five control knobs, and dial mechanism cover.

2. Unsolder the three leads from the potentiometer terminals. Remove the three small screws which hold the coiled wire bracket to the back of the potentiometer. The coiled wire is now free.

3. Rotate F_1 knob full counterclockwise (CCW) and the F_2 knob full clockwise (CW).

4. Loosen F_2 potentiometer gear hub set screws on both gear hubs.

5. Remove F_2 potentiometer by turning the potentiometer case in a clockwise direction as viewed from the shaft end.

6. Insert new potentiometer and tighten by turning in a counterclockwise direction.

7. Tighten set screws on gear hub closest to the mounting plate.

8. Disengage the idler gear connecting the F_1 potentiometer shaft gear to the F_2 potentiometer body gear.

9. Set the upper mechanical stop. This stop can be seen as a bent tooth on the gear on the F_2 potentiometer shaft and a small extension on the F_2 dial indicator shaft gear. The stop must be set below the center line of the F_2 dial indicator gear and the F_2 potentiometer gear as the F_2 knob turns clockwise.

   It may take a few attempts but no difficulty should be encountered.

10. Tighten the potentiometer shaft gear set screws.

11. Rotate the F_2 knob counterclockwise until the F_2 indicator is approximately 1/64" from the

F_1 indicator. Now, while holding the F_2 knob so as to maintain the 1/64" distance, rotate the entire F_2 potentiometer counterclockwise (CCW) until the mechanical stop is felt. If the indicators touch because the F_2 knob was allowed to turn after the stop was reached a slight clockwise turn on the F_2 knob will separate them.

12. Very carefully engage the idler gear between the F_1 potentiometer shaft gear and the F_2 potentiometer body gear (the one closest to the mounting plate) and tighten set screws.

    The lower and upper mechanical stops are now set. A gap should be maintained between indicators over the entire distance of the dial. Adjustments should be made beginning with Step 8 if gap is not maintained.

13. After the stops have been set, run the F_2 indicator full clockwise (CW) and the F_1 indicator to approximately 50 on the logging scale.

14. Remove the three screws from the back of the F_2 potentiometer.

CAUTION: Do not let the back of the potentiometer come off.

15. Secure the coiled wire bracket to the back of the potentiometer, and solder the three leads to the potentiometer terminals.

4.7.3 REPLACEMENT OF M_2 POTENTIOMETER

NOTE: Removal of the M_1 , M_2 or F_0 potentiometer, requires dropping the front panel forward.

Remove the top cover, the right and left handle sides, the five control knobs and the dial mechanism cover. Remove the screws from the periphery of the front panel. Remove the screws which hold the coiled cable to the side of the instrument. Remove any applicable rf connections.

Drop front panel forward.

1. Unsolder the wires to potentiometer terminals.
2. Turn the M_2 and M_1 knobs full counterclockwise (CCW).
3. Remove retaining ring and thrust washer from the M_2 knob shaft.
4. Loosen the two set screws on the M_2 knob shaft gear hub.
5. Loosen the M_2 dial cord hub and press M_2 knob shaft about halfway out.
6. Loosen potentiometer shaft gear hub set screws.
7. Remove potentiometer retaining nut and washer and remove M_2 potentiometer remembering orientation of potentiometer terminals.
8. Position idler gear (with planetary gear) and new potentiometer shaft full clockwise (CW) as viewed from the front panel.
9. Insert new potentiometer and tighten retaining nut remembering potentiometer orientation.
10. Engage potentiometer shaft gear and tighten set screws. Make sure the potentiometer shaft is full clockwise (CW).
11. Press M_2 knob shaft into place and replace thrust washer and retaining ring.
12. Engage M_2 knob shaft gear with idler gear and potentiometer shaft gear.
13. Tighten set screws on M_2 knob shaft gear.
14. Rotate M_2 knob fully counterclockwise (CCW).
15. Rotate M_2 dial cord CCW until dial indicators are approximately 1/64" apart.

16. Tighten M_2 dial cord drum set screw.

7.4 REPLACEMENT OF THE M_1 POTENTIOMETER

1. Remove the Helix Overcurrent PC Board assembly. This will permit a wrench to be inserted from the left side of the gear assembly as viewed from the front of the unit.
2. Position M_1 and M_2 CONTROL knobs full CCW. Note position of indicators.
3. Loosen the M_1 potentiometer shaft gear hub set screws.
4. Remove M_1 potentiometer retaining nut and withdraw M_1 potentiometer, remembering orientation of potentiometer terminals.
5. Insert new potentiometer. Tighten retaining nut.
6. Replace M_1 potentiometer shaft gear making sure that the M_1 indicator is in previous position and the M_1 potentiometer shaft is full clockwise (CW).
7. Tighten set screws on potentiometer shaft gear.
8. Replace Helix Overcurrent PC Board.
9. Resolder leads.

7.5 REPLACEMENT OF THE F_0 POTENTIOMETER

1. Rotate the F_1 , F_0 and F_2 control knobs full counterclockwise (CCW).
2. Unsolder the leads to the F_0 potentiometer terminals.
3. Remove the F_1 knob shaft retaining ring and thrust washer.
4. Loosen the F_1 dial cord drum set screws remembering the exact position of F_1 indicator.
5. Move F_1 knob shaft forward disengaging F_1 knob shaft gear. Loosen F_1 knob shaft gear hub set screws.
6. Slide F_1 knob shaft forward until inner locking ring bottoms on F_1 knob shaft gear.
7. Loosen set screws on F_0 potentiometer shaft gear.
8. Loosen potentiometer retaining nut.
9. Withdraw potentiometer remembering orientation of potentiometer terminals.
10. Insert new potentiometer positioning shaft full clockwise (CW) as viewed from the shaft end.
11. Tighten potentiometer retaining nut.
12. Engage F_0 potentiometer shaft gear and tighten two set screws.
13. Loosen set screw on F_0 dial cord drum and note position of indicator. Rotate F_0 knob full counterclockwise (CCW). The stop of the potentiometer should be felt.
14. Position the F_0 indicator to position as noted in Step 13.
15. Tighten F_0 dial cord drum set screw.
16. Replace F_1 knob shaft into position and replace thrust washer and retaining ring.
17. With the F_1 potentiometer shaft fully clockwise (CW), slide the F_1 knob shaft gear up and intermesh with F_1 potentiometer shaft gear. Tighten gear set screws.
18. Rotate F_1 knob shaft fully counterclockwise (CCW) and tighten F_1 dial cord drum after positioning indicator as it was before Step 4 above.

19. Resolder leads

4.8 BACKWARD WAVE OSCILLATOR TUBE ADJUSTMENT

1. Replace the backward wave oscillator tube per paragraph 4.6.
   Do not connect to the power supply.

2. Turn the POWER switch to ON and adjust the ANODE and GRID voltages to the value specified for the new tube.
   It may be necessary to replace resistor R829 in order to obtain correct ANODE voltage. The correct value of R829 can be determined per Chart A. Check HEATER voltage for approximately 6.6 volts at (+) TP7 and (-) TP8.

CAUTION: These voltages are referenced to the cathode which is at a high voltage with respect to ground. Use a floating voltmeter.

Chart A

BWO Anode Voltage	R829*
206 - 264	402 K Ω
182 - 237	249 K Ω
158 - 207	165 K Ω
138 - 180	121 K Ω
122 - 160	93.1 K Ω
107 - 140	73.2 K Ω
95 - 125	60.4 K Ω
70 - 90	38.8 K Ω
64 - 85	34.8 K Ω
56 - 75	29.4 K Ω
59 - 66	25.5 K Ω

* 1/2 %, 1/2 watt, metal film

3. Turn the POWER switch to OFF and connect the backward wave oscillator tube to the power supply (P920 to J920). Monitor the HEATER VOLTAGE.

4. Turn the POWER switch to ON. Adjust the HEATER to 6.3 volts using R824 (see Figure 4-4).

5. Connect a power meter as shown in Figure 4-8.

6. Check the unleveled power output across the entire frequency band.

CAUTION: Do not exceed the thermistor power rating.

7. If the power is below specifications at any point, increase the ANODE voltage using the ANODE ADJUST, R806. (See para 4.1.5 step 4.)

8. For leveled units, check the leveled power output and power variation across the entire frequency band.

9. If the unit does not meet the leveled output specification, make adjustments per para 4.3.3 and para 4.1.5.

10. Set FREQUENCY mode selector to SWEEP; $F_1 \rightarrow F_2$,

    set SWEEP; TIME to 0.1 seconds,

    set F_1 FREQUENCY control to 0 on logging scale,

    set F_2 FREQUENCY control to 100 on logging scale,

    and METER control to RF UNLEVELED.

11. Connect an oscilloscope to the unit as shown in Figure 4-8.

12. Set RETRACE control to OFF. The rf should be off during the entire retrace period. If it is not, increase the GRID voltage using R818

(GRID BIAS MAX ADJUST) so that this condition is met.

13. Set the MODULATION control to SQUARE WAVE. The rf should be off during the off portion of the square wave over the entire frequency band. If not, increase the GRID voltage slightly using R818.

14. Connect the power meter as shown in Figure 4-8. Measure the power output and power variation across the entire band during LEVELED operation. Use slow sweep or manual control.

15. Disconnect the power meter and connect an oscilloscope as shown in Figure 4-8.

16. Set FREQUENCY mode selector to SWEEP; $F_0 \pm \Delta F$, set SWEEP; time to 0.1 seconds and adjust the POWER SET control for calibrated power output.

17. Set F_0 FREQUENCY indicator to 0 on logging scale, and set the frequency meter to the frequency corresponding to this setting.

18. Adjust the START FREQUENCY ADJUSTMENT (R125) so that the frequency meter marker pip is in the center of the oscilloscope face.

    NOTE: ΔF AMPLITUDE control should be full on (clockwise).

19. Reduce the ΔF AMPLITUDE control while adjusting R125 so the pip remains in the center.

20. Move F_0 FREQUENCY indicator to 100 on the logging scale and set the frequency meter to the frequency corresponding to this setting.

21. Adjust the END FREQUENCY ADJUSTMENT (R121) so that the frequency meter marker pip is in the center of the oscilloscope face.

    NOTE: ΔF AMPLITUDE control should be full on (clockwise).

22. Reduce the ΔF AMPLITUDE control while adjusting R121 so the pip remains in the center.

23. Repeat Steps 16 through 22. Repeating the steps is necessary because of the interaction of R125 and R121.

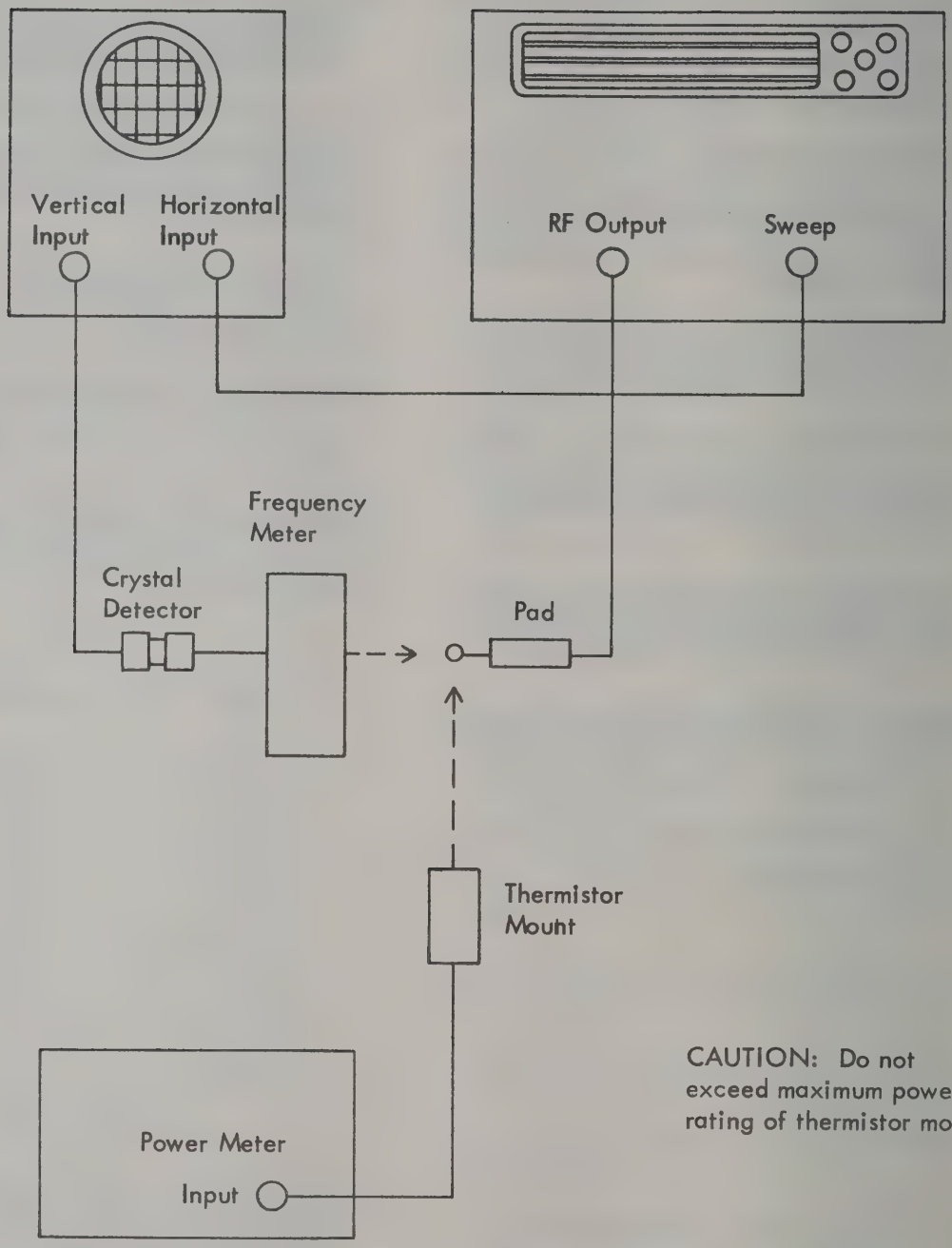


Figure 4-8. BWO Tube Adjustment.

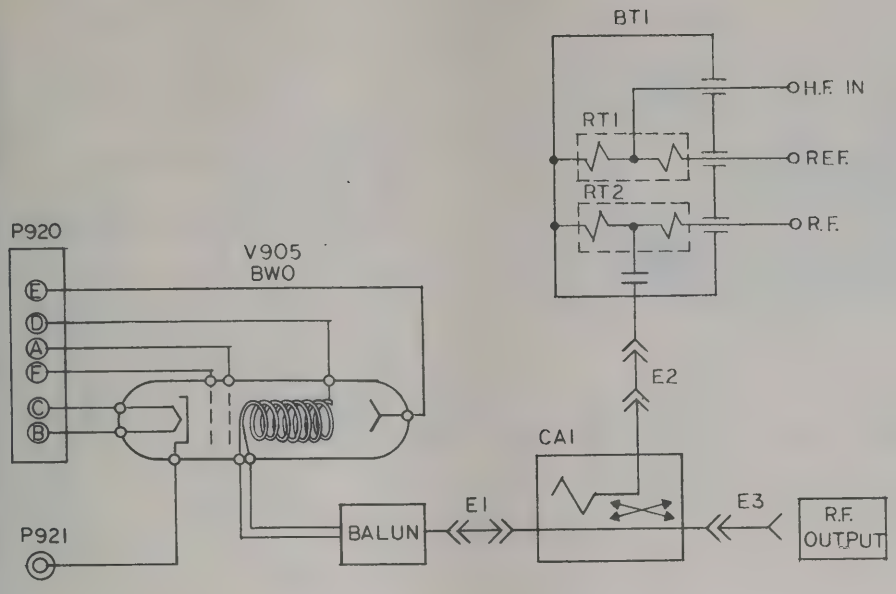


FIG. 5-1. RF Circuit Diagram.

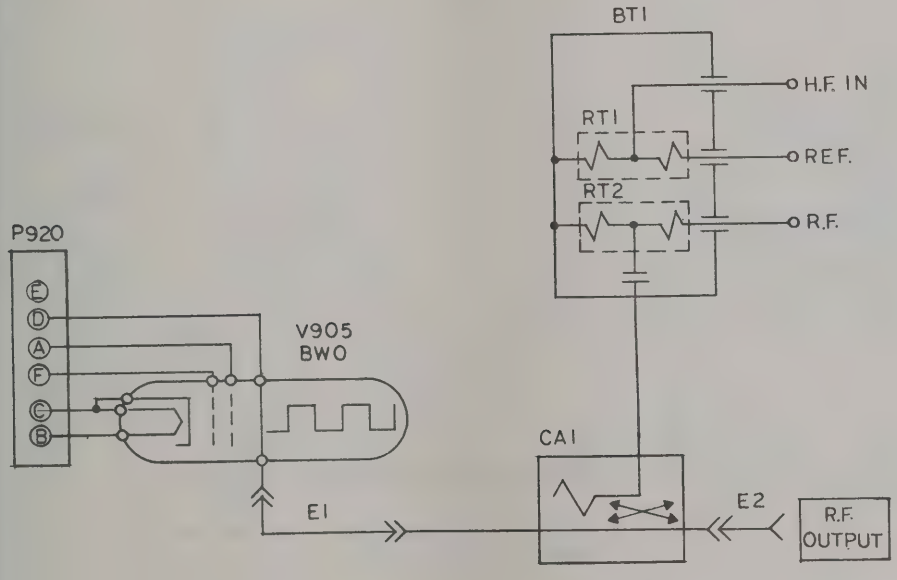


FIG. 5-2. RF Circuit Diagram.

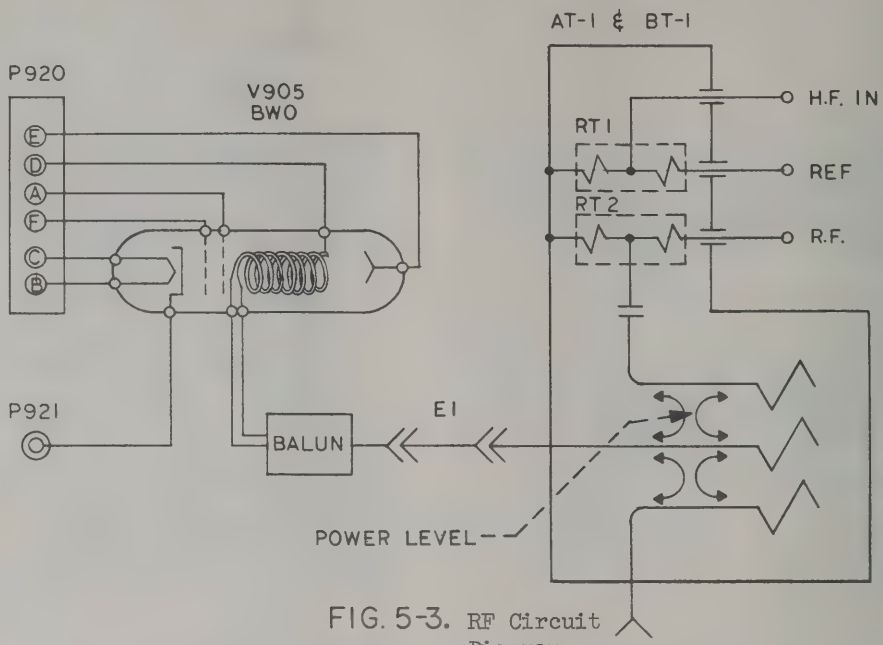


FIG. 5-3. RF Circuit Diagram.

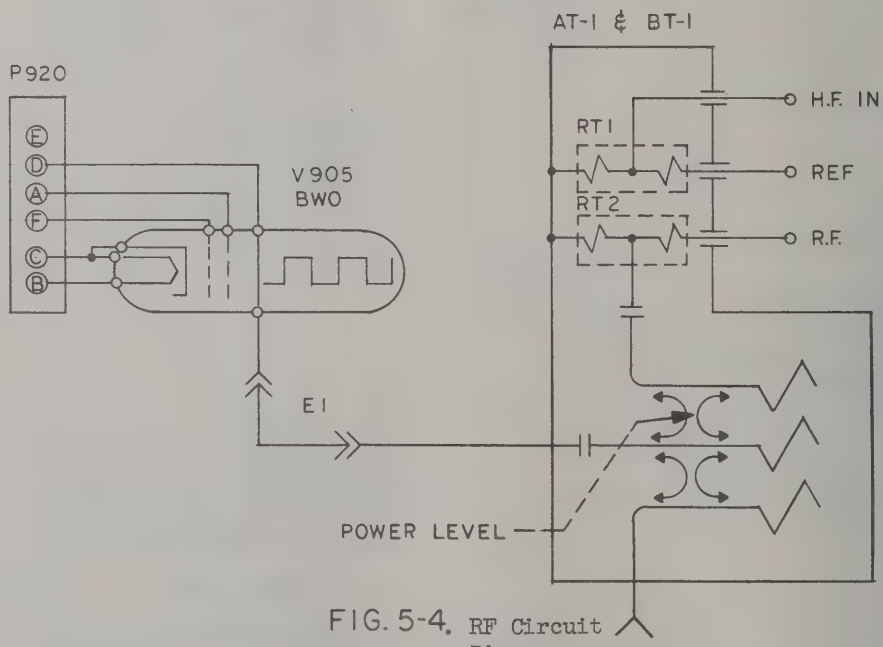


FIG. 5-4. RF Circuit Diagram.

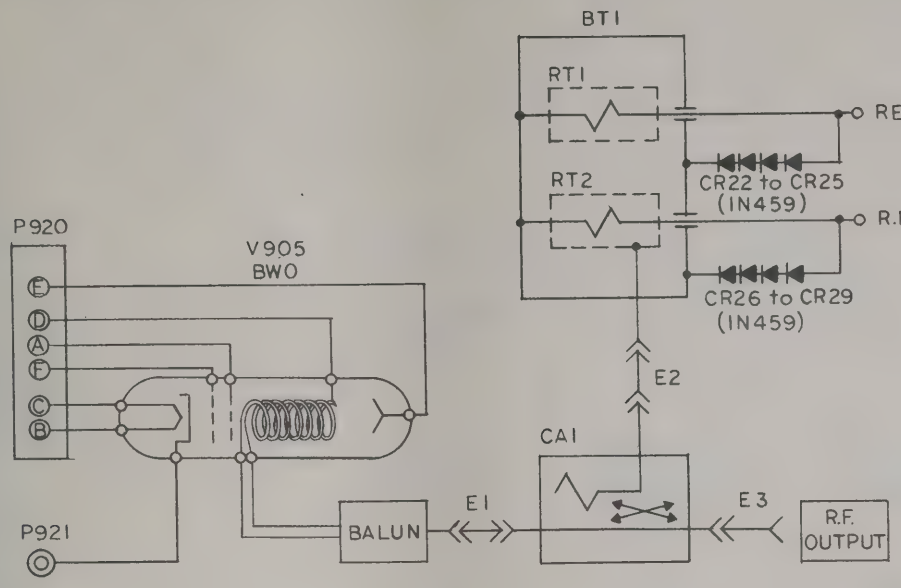


FIG. 5-5. RF Circuit Diagram.

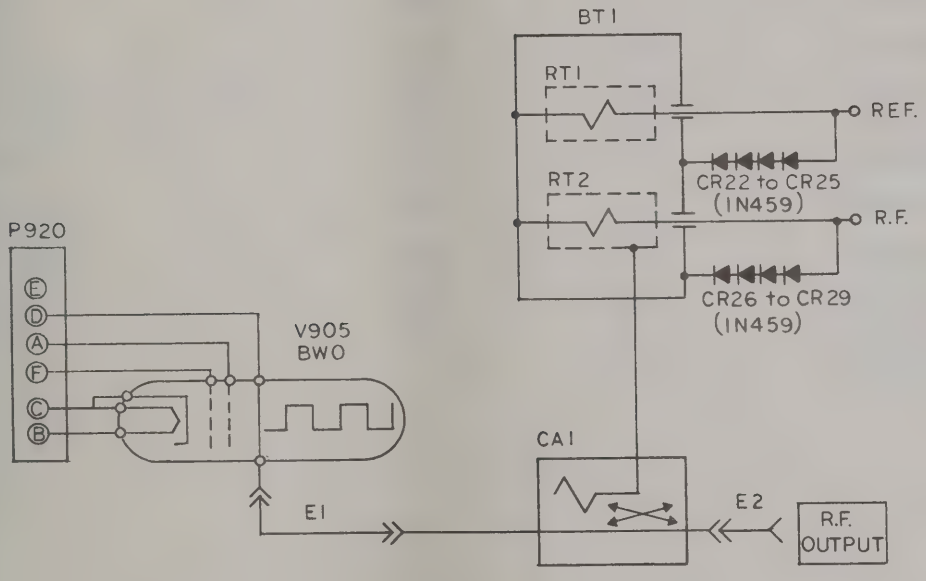


FIG. 5-6. RF Circuit Diagram.

SECTION 6

SCHEMATICS

Circuit	PC Board Number	Reference Designation Prefix	Schematic Number
Diode Shaper	10	10	900604B
Cathode Supply	100	100	900599C
Low Voltage Power Supplies	200	200	900766C
Sweep Circuit	300	300	900600C
Markers Circuit	400	400	900652C
Reference Oscillator & Modulator	500	500	900661C
Leveler Circuit	600	600	900602C
Helix Overcurrent	700	700	900598C
Transfer Oscillator	750	750	900597C
Elevated Supply	800	800	900673C
Chassis	-	900	900660 D

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WASHINGTON, D. C., 10 *August* 1967

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USAMB (1)
USACDCEC (1)
USACDCCEA (1)
USACDCCEA:
Ft Huachuca (1)
Eighth USA (5)
SAAD (5)
TOAD (5)
LEAD (3)
USASCS (100)

NG: None.

USAR: None.

For explanation of abbreviations used, see AR 320-50.

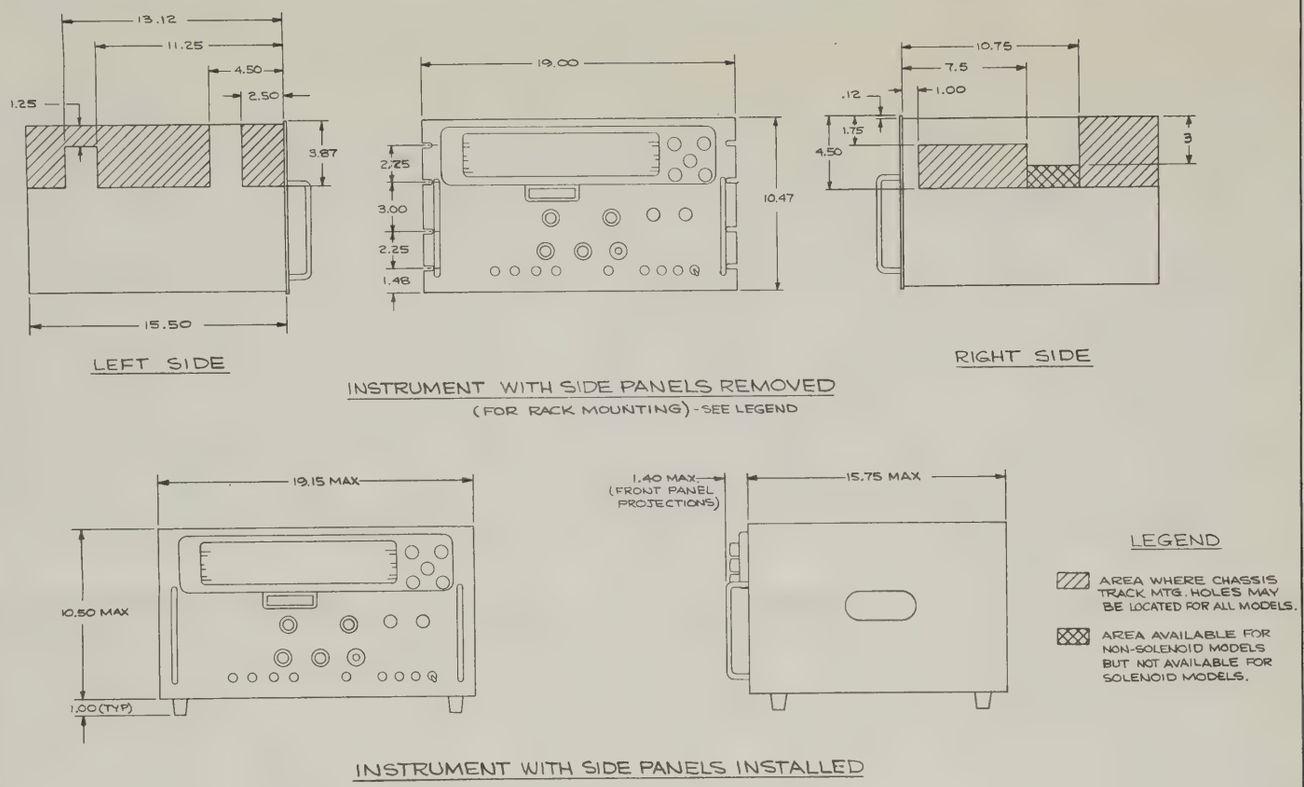
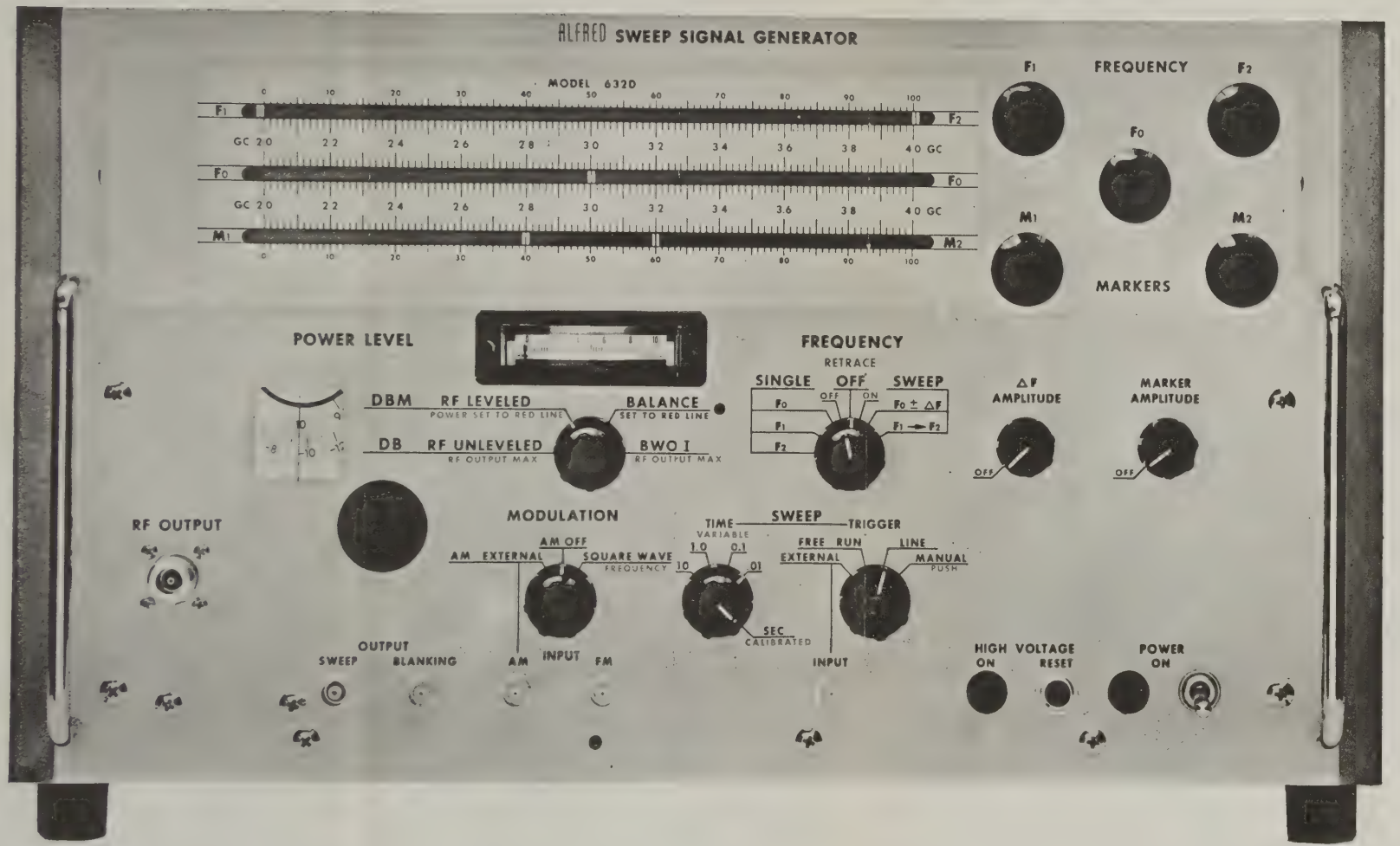


Figure 1-1. Outline and Dimensional Data for Model 630 Series Instrument.

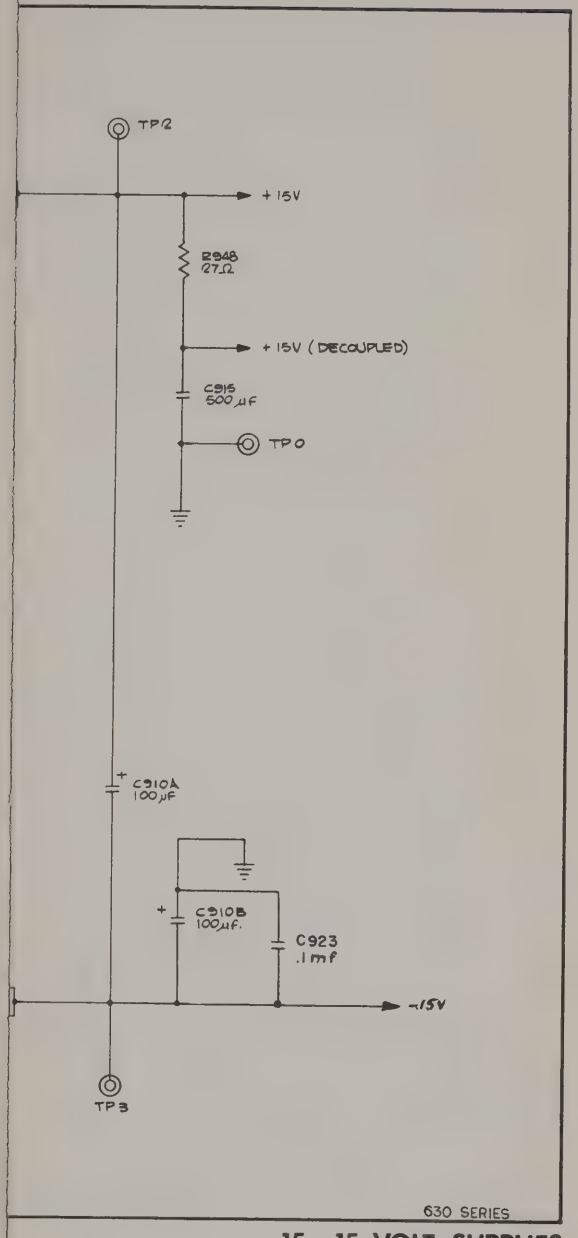
NOTES:

1. THE MODEL 630 SERIES INSTRUMENT MAY BE EITHER BENCH MOUNTED OR RACK MOUNTED.
2. FOR RACK MOUNTING REMOVE BOTH SIDE PANELS.
3. FOR INSTALLATION OF CHASSIS TRACKS, DRILL MTG. HOLES ONLY IN SHADED AREAS INDICATED ABOVE.
4. APPROXIMATE WEIGHT OF INSTRUMENT IS 60 LBS. (SLIGHTLY HEAVIER FOR SOLENOID MODEL INSTRUMENTS).

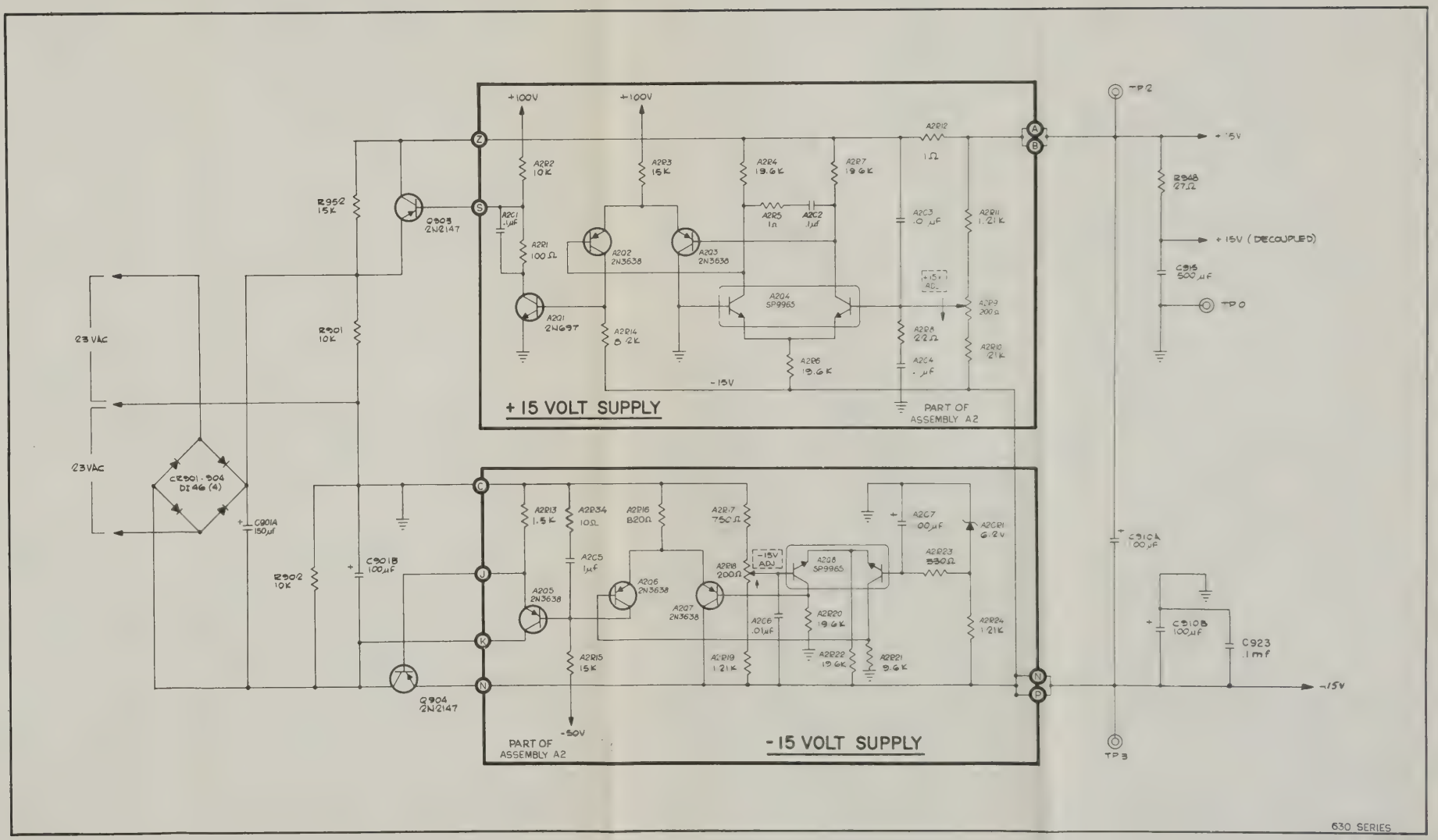


FRONT PANEL

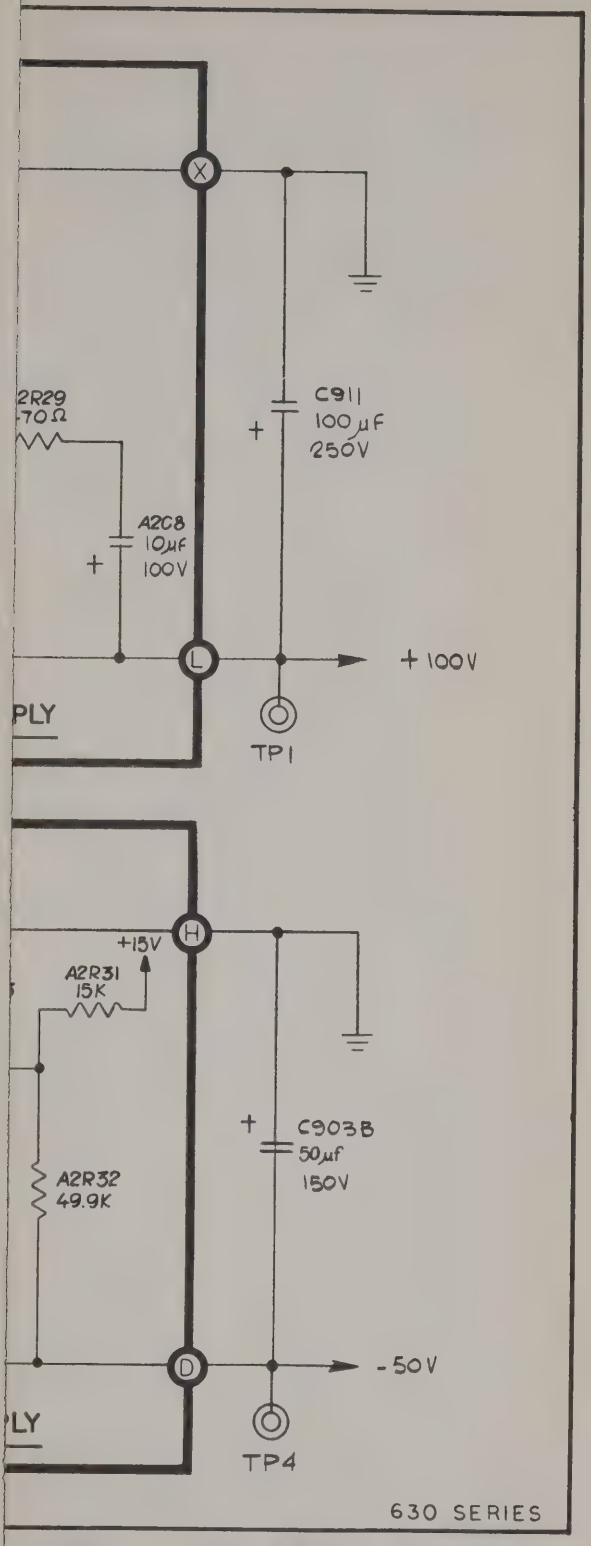
FIGURE 2-1



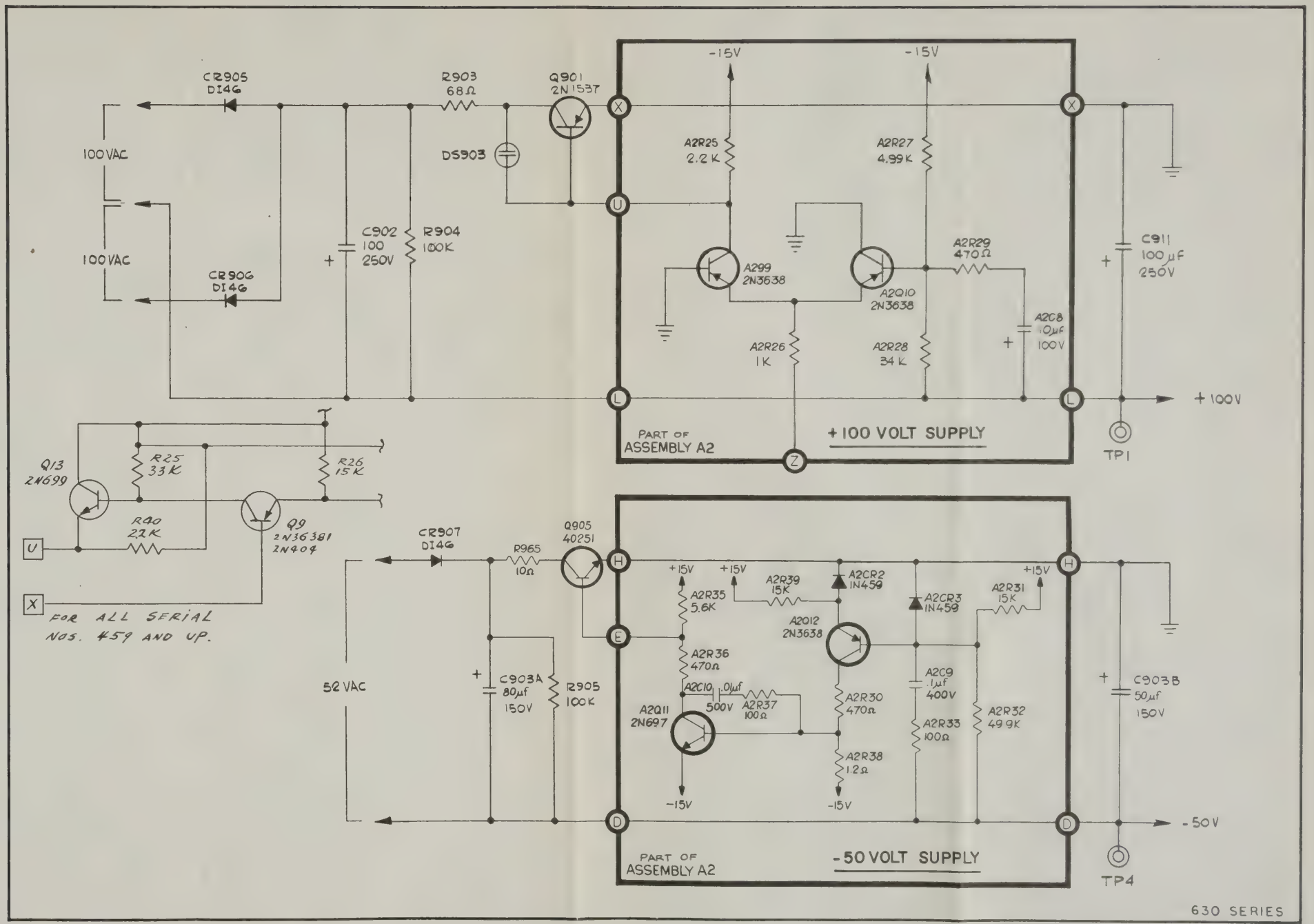
+15, -15 VOLT SUPPLIES
FIGURE 3-3



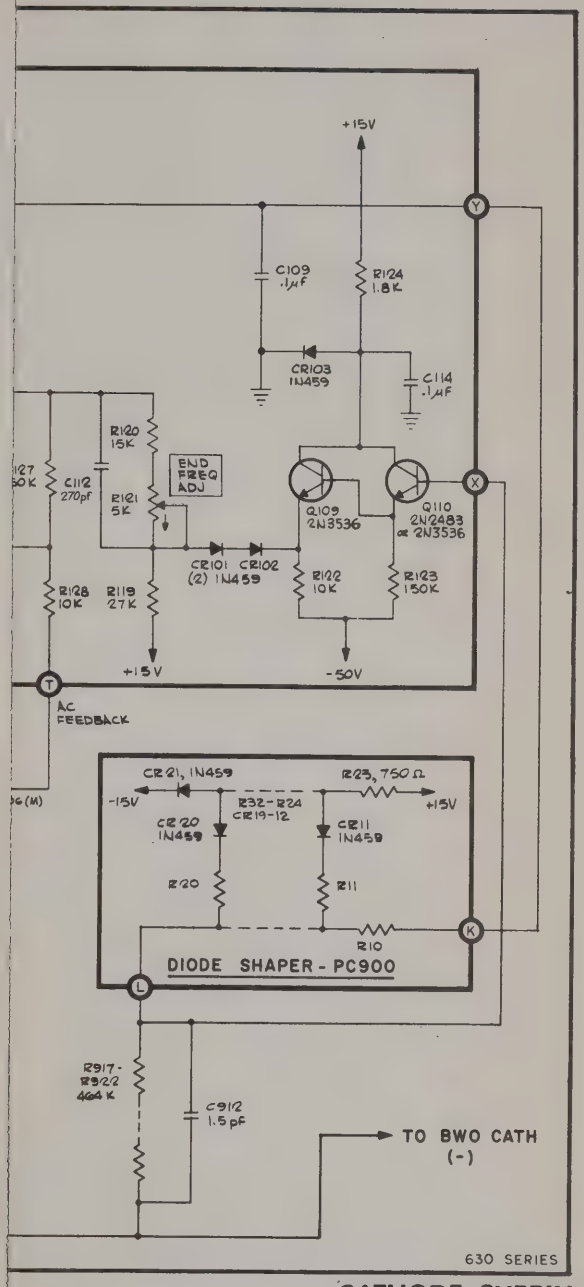
+15, -15 VOLT SUPPLIES
FIGURE 3-3



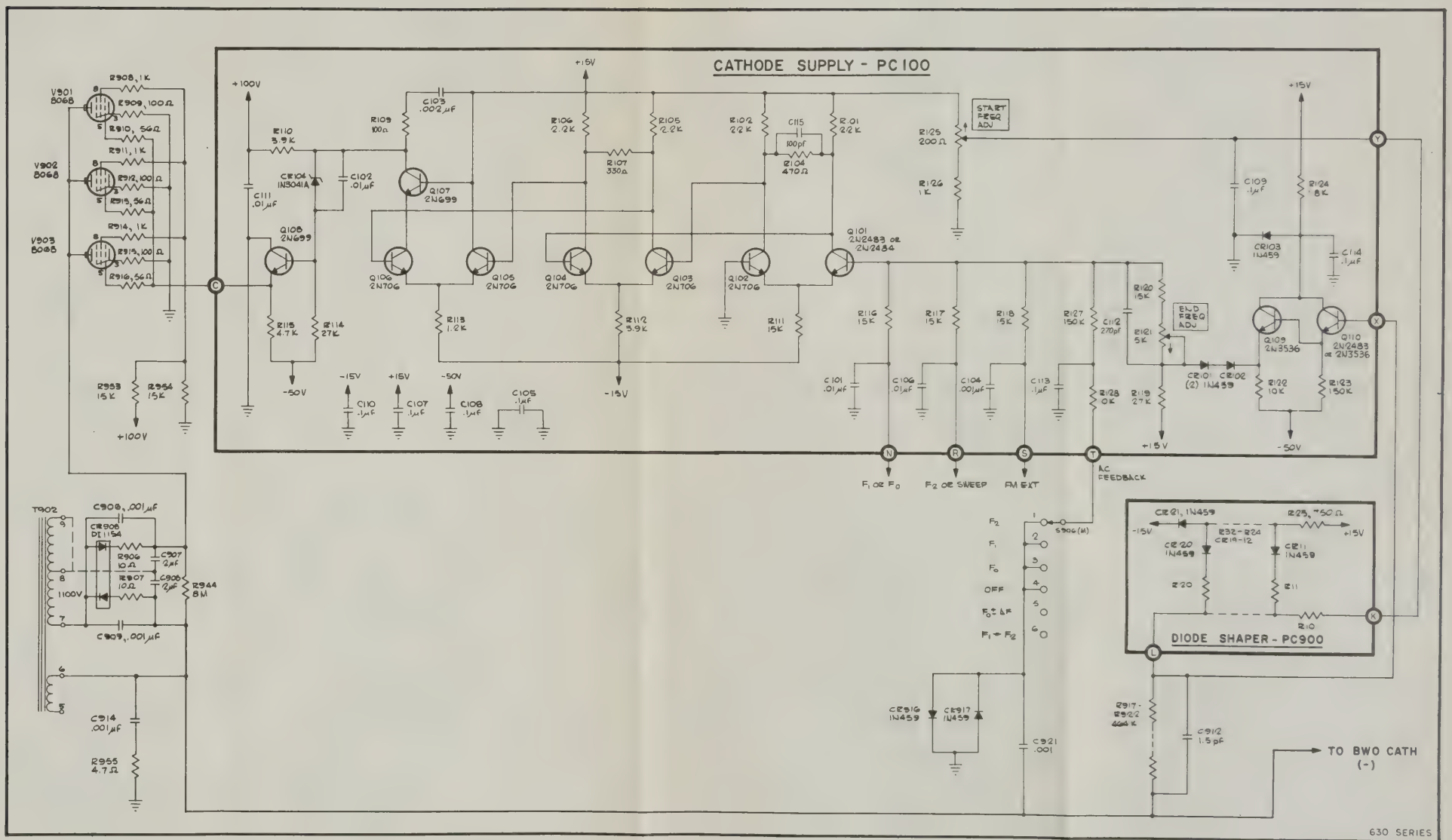
+100, -50 VOLT SUPPLIES
FIGURE 3-4



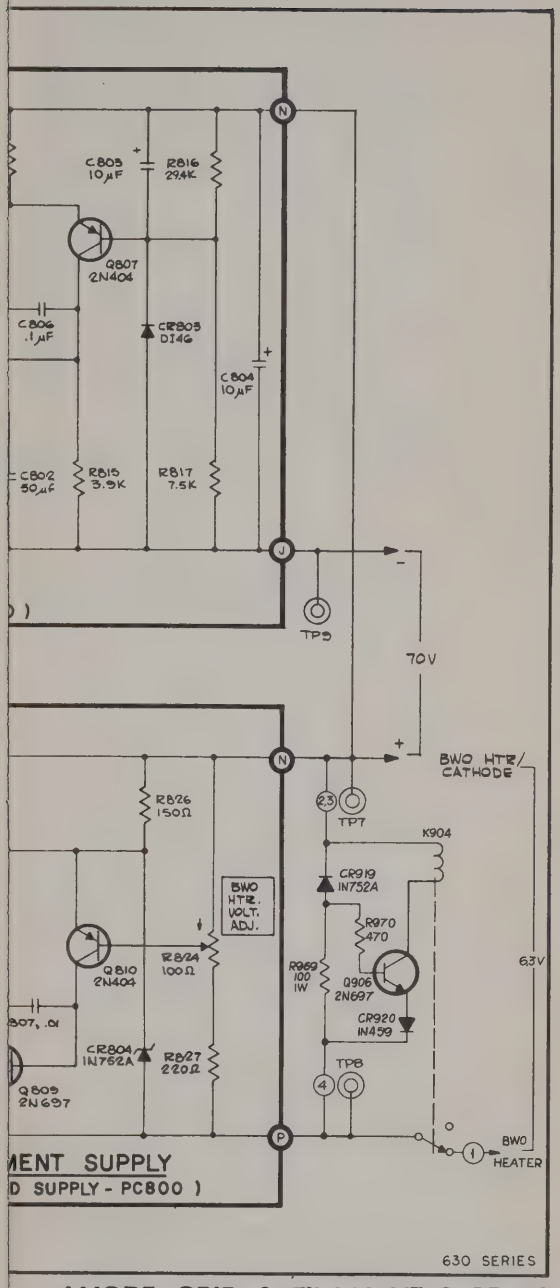
+100, -50 VOLT SUPPLIES
FIGURE 3-4



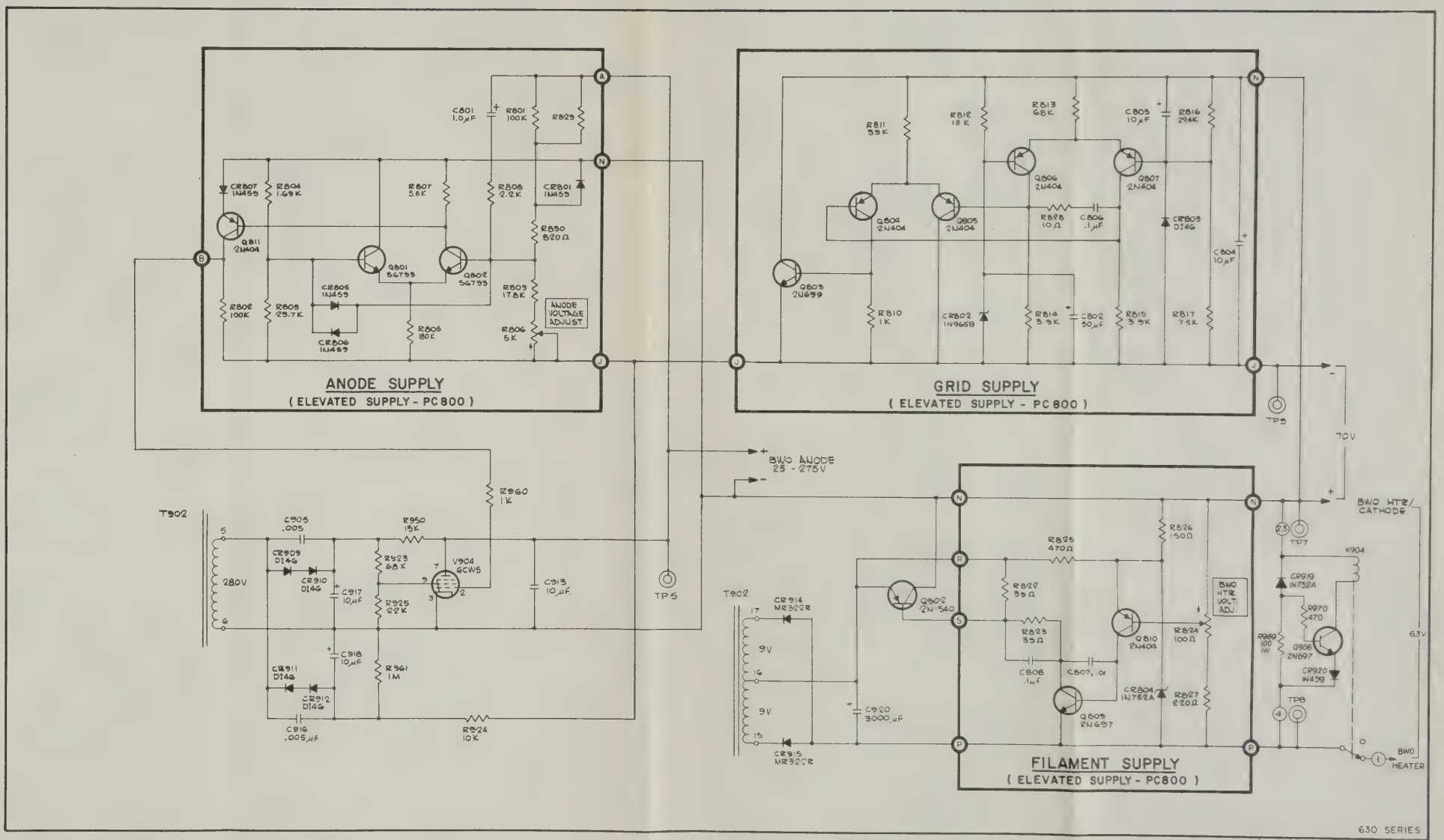
CATHODE SUPPLY
FIGURE 3-5



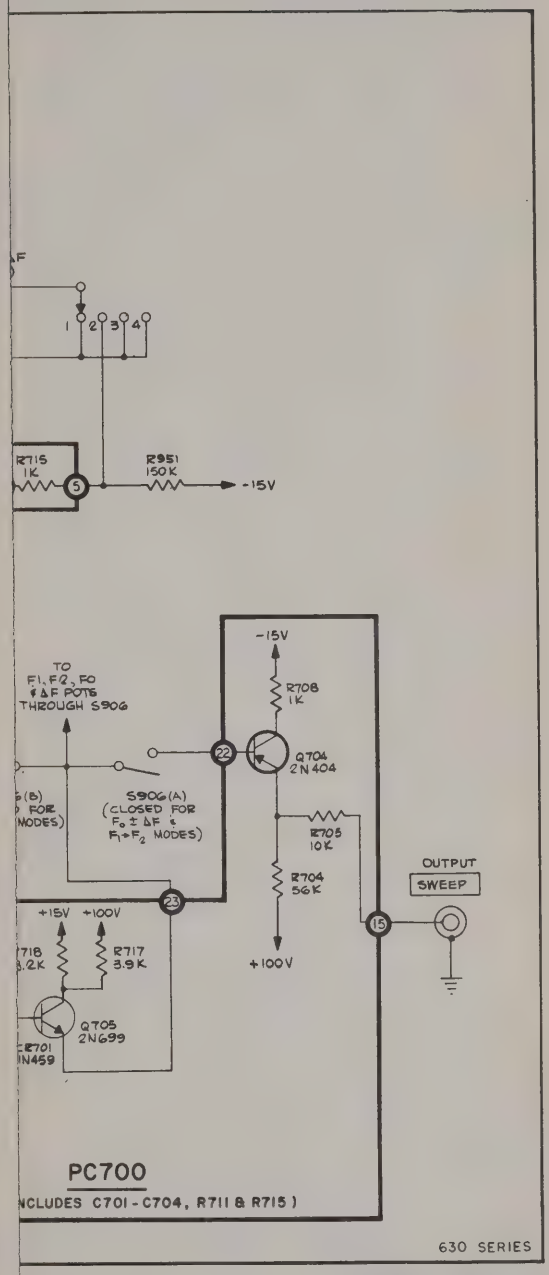
CATHODE SUPPLY
FIGURE 3-5



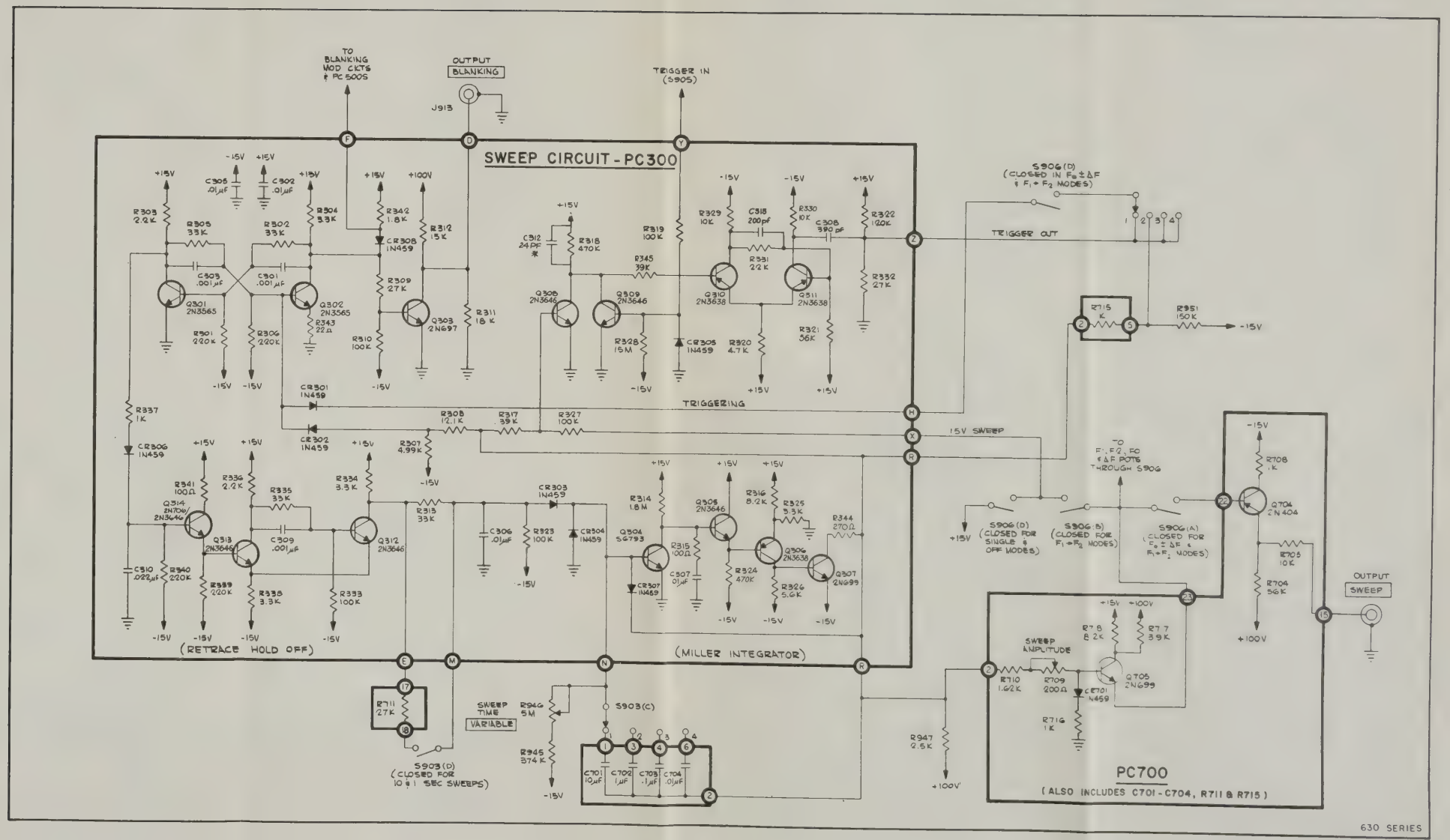
ANODE, GRID & FILAMENT SUPPLIES
FIGURE 3-6



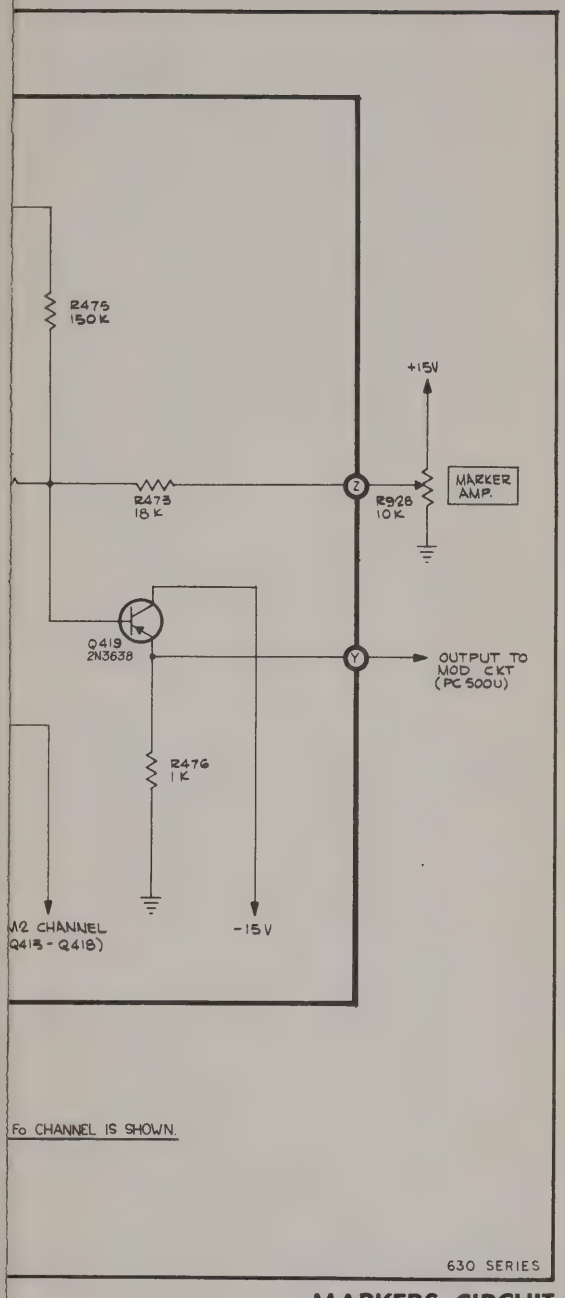
ANODE, GRID & FILAMENT SUPPLIES
FIGURE 3-6



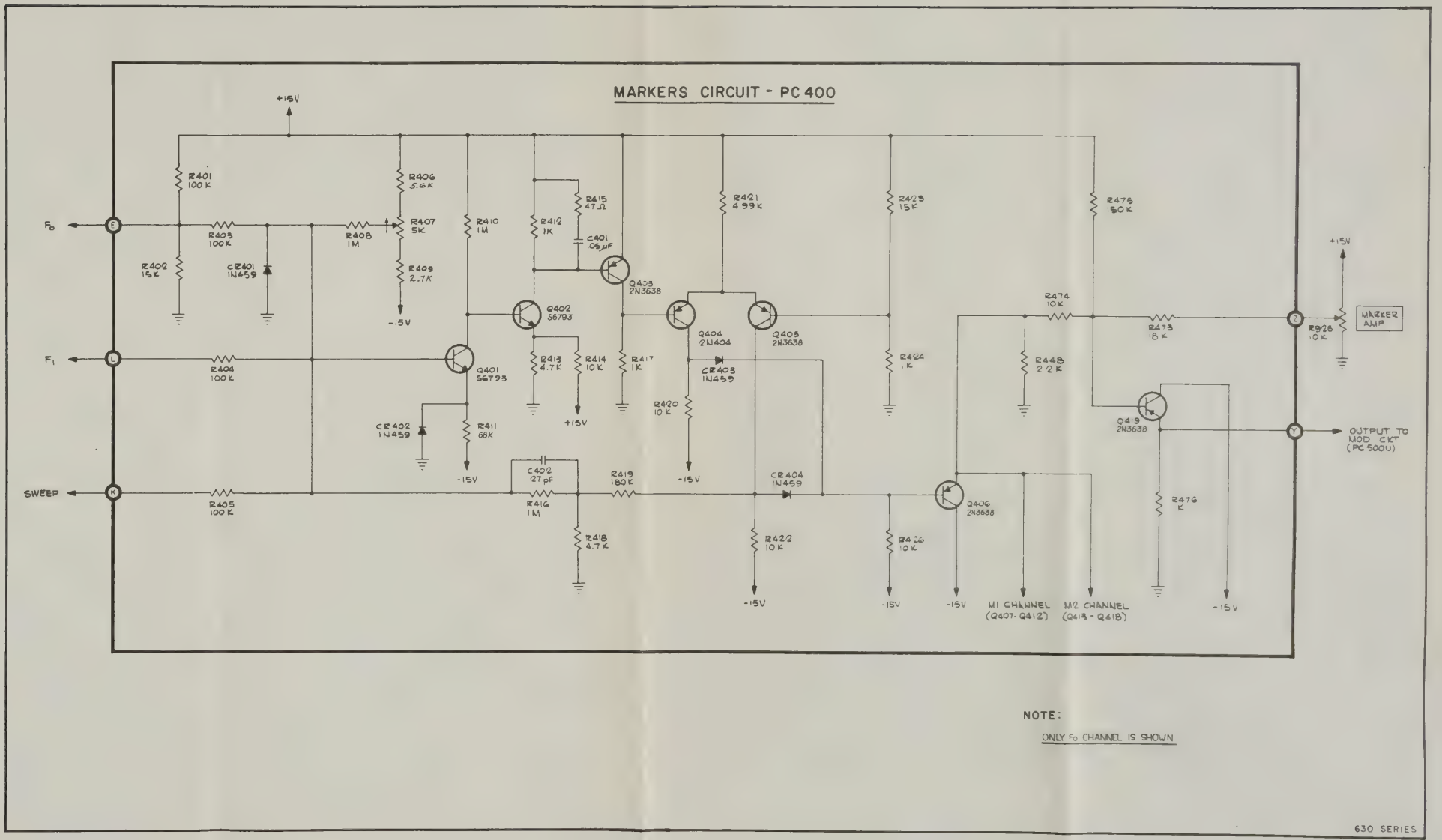
SWEEP CIRCUIT
FIGURE 3-7



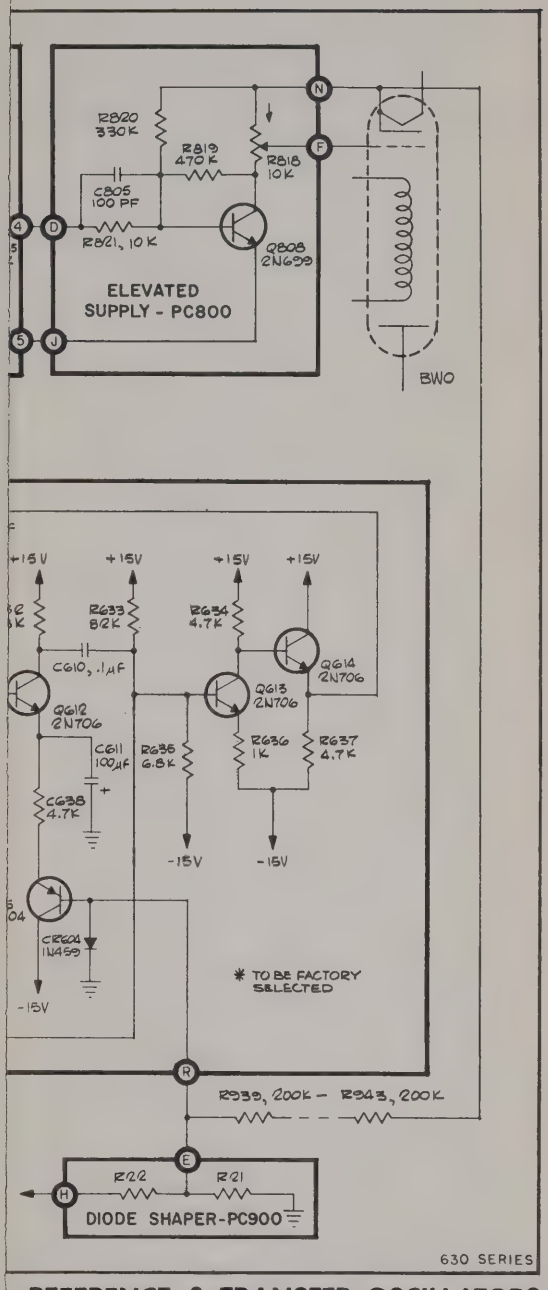
SWEEP CIRCUIT
FIGURE 3-7



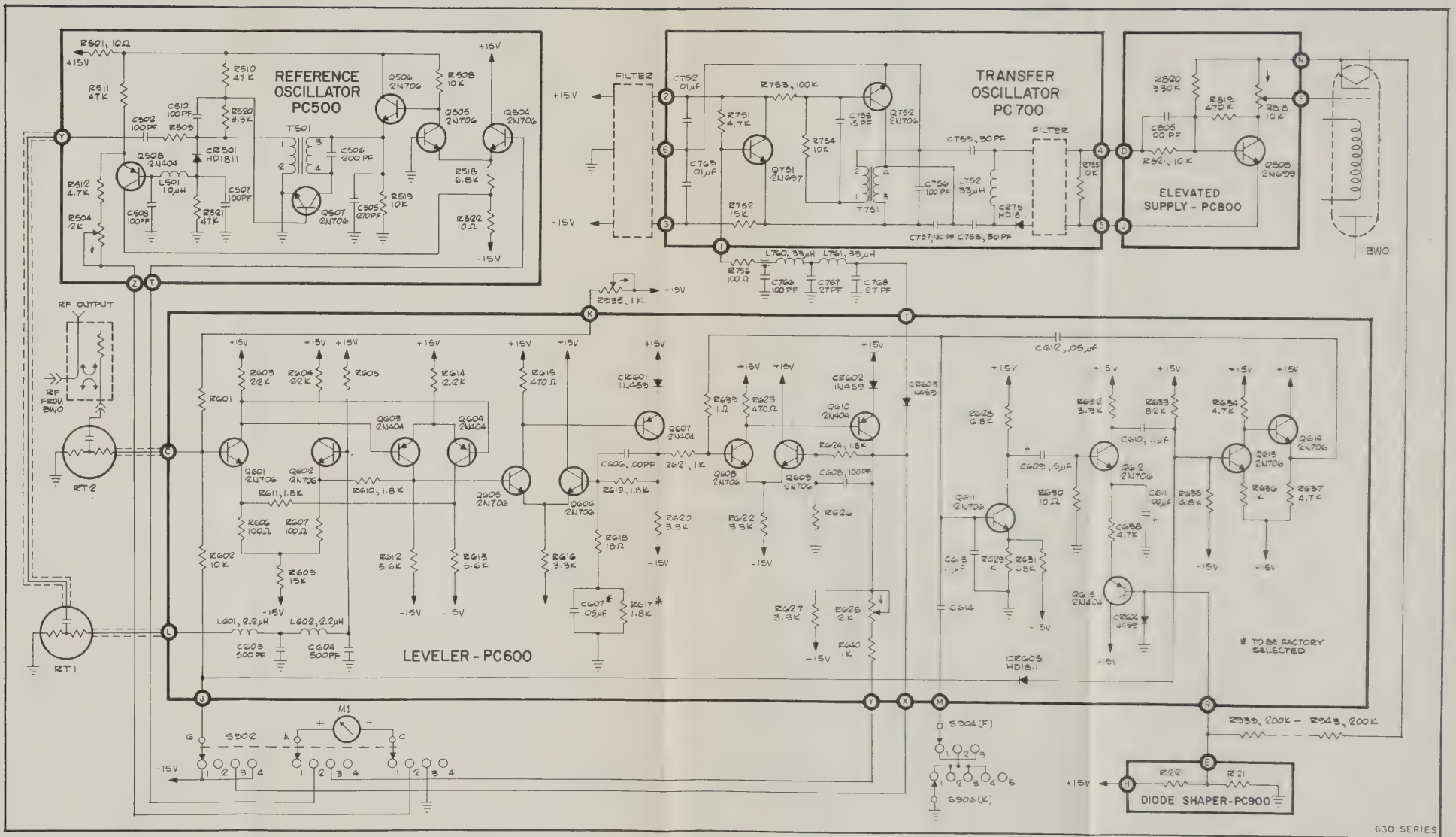
MARKERS CIRCUIT
FIGURE 3-8



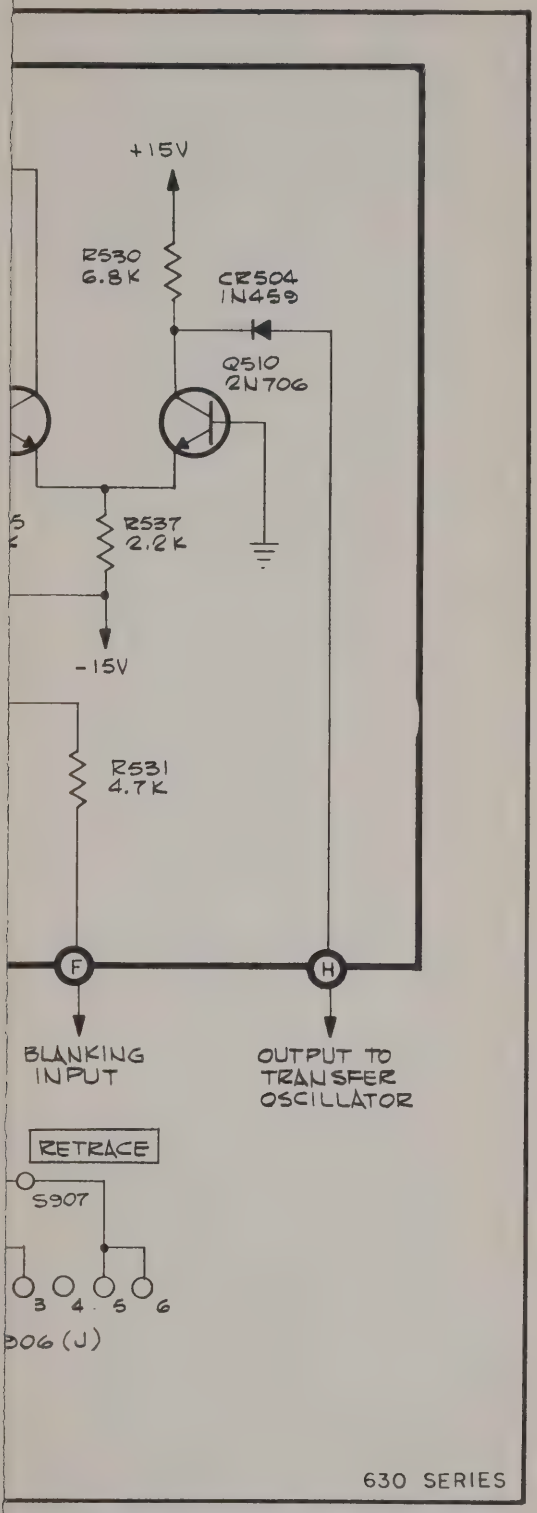
MARKERS CIRCUIT
FIGURE 3-8



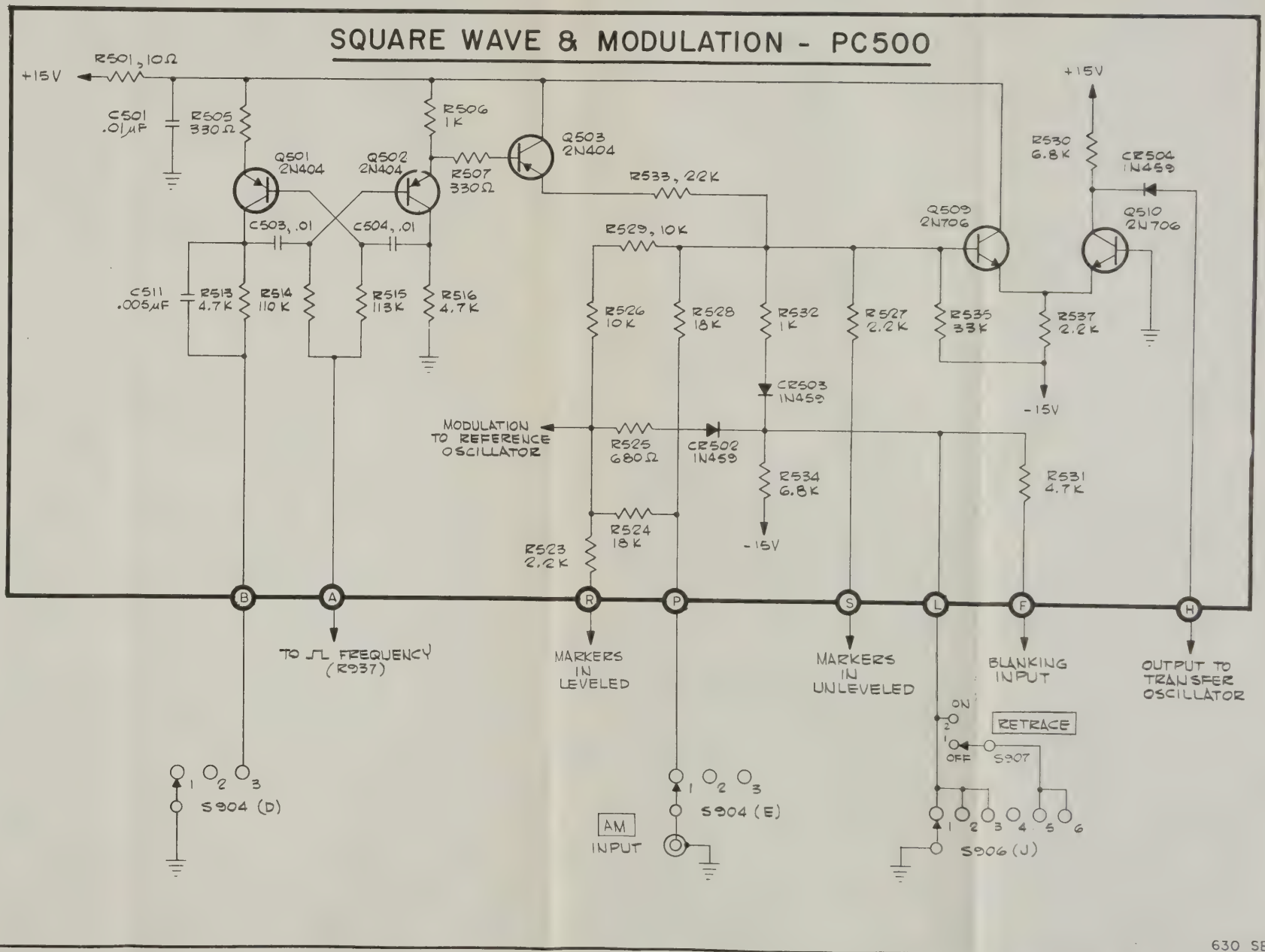
REFERENCE & TRANSFER OSCILLATORS AND LEVELER CIRCUIT FIGURE 3-9



REFERENCE & TRANSFER OSCILLATORS AND LEVELER CIRCUIT
FIGURE 3-9



RE WAVE & MODULATION
FIGURE 3-10



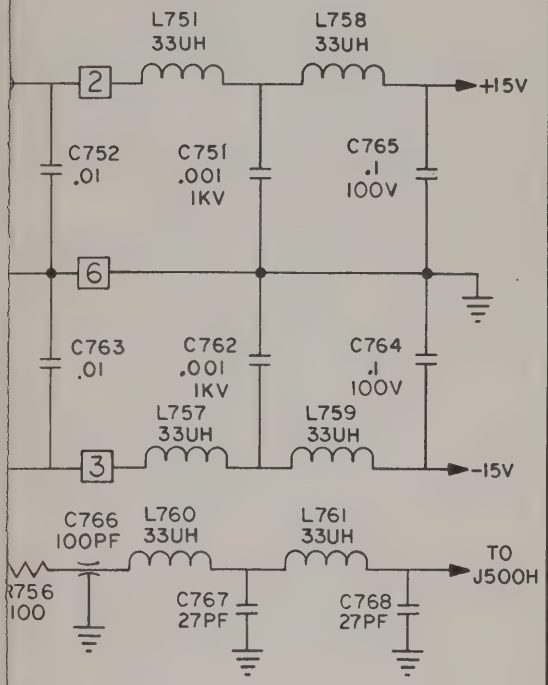
SQUARE WAVE & MODULATION
FIGURE 3-10

E_2	E_3	RF CIRCUIT DIAGRAM
		5-1
		5-1
		5-3
		5-3
		5-1
		5-3
	RF cable assembly 950356B-1	5-1
	RF cable assembly 950356B-1	5-1
		5-3
		5-3
		5-1
Coax to WG Adapter 253-1	Bend 950627B	5-1
Bend 950627B		5-2
	Bend 950628B	5-5
Bend 950628B		5-6

Section 5. CHARTS AND RF CIRCUIT DIAGRAMS

CHART #1
Information for Individual 630 Models

MODEL NUMBER	T902	R933	S913 HELIX/DELAY LINE (FULL SCALE)	J900 HELIX-SHAPER BOARD	V905 BWO	AT1 ATTENUATOR	CA1 COUPLER	BT1 BOLOMETER MOUNT	RT1 BARRETTER	RT2 BARRETTER	CURRENT TRIP-OUT VALUE	E_1	E_2	E_3	RF CIRCUIT DIAGRAM
631AB	7&8	12.5Ω	5 ma	950373	SE214C		950421 (17 db)	Model F101	Filmohm MWB450-HF	Filmohm MWB450-HF	5 ma				5-1
631AB-S1	7&8	12.5Ω	5 ma	950848	SE219-3		950421 (17 db)	Model F101	Filmohm MWB450-HF	Filmohm MWB450-HF	5 ma				5-1
631DB	7&8	12.5Ω	5 ma	950373	SE214C	SA-3			Filmohm MWB450-HF	Filmohm MWB450-HF	5 ma				5-3
631DB-S1	7&8	12.5Ω	5 ma	950848	SE219-3	950521			Filmohm MWB450-HF	Filmohm MWB450-HF	5 ma				5-3
632AB	7&9	12.5Ω	5 ma	950718	SE215A-2		950420 (17 db)	Model F101	Filmohm MWB450-HF	Filmohm MWB450-HF	3.5 ma				5-1
632DB	7&9	12.5Ω	5 ma	950718	SE215A-2	SA-4			Filmohm MWB450-HF	Filmohm MWB450-HF	3.5 ma	3 db Attenuator 252-4			5-3
633AB	7&9	12.5Ω	5 ma	950323	SE211A-8		Narda 3044-10 (10 db)	Model F101	Filmohm MWB450-HF	Filmohm MWB450-HF	3.5 ma	LP Filter (FL1) RLC F-30 (8 Gc) 256-3		RF cable assembly 950356B-1	5-1
633AB-S1	7&9	12.5Ω	5 ma	950524	SE221-1		Selected Narda 3044-10 (10 db)	Model F101	Filmohm MWB450-HF	Filmohm MWB450-HF	3.5 ma	UG57B/U		RF cable assembly 950356B-1	5-1
633DB	7&9	12.5Ω	5 ma	950323	SE211A-1	SA-5			Filmohm MWB450-HF	Filmohm MWB450-HF	3.5 ma	LP Filter (FL1) RLC F-30 (8 Gc) 256-1			5-3
633DB-S1	7&9	12.5Ω	5 ma	950524	SE221-1	950522			Filmohm MWB450-HF	Filmohm MWB450-HF	3.5 ma	Filter (FL1) Microlab #LA70N (7 Gc) 256-4			5-3
634AB	7&9	12.5Ω	5 ma	950371	SE209-1		Narda 2846 (10 db)	Model F101	Filmohm MWB450-HF	Filmohm MWB450-HF	3.5 ma	Coax cable 950871C-3			5-1
635AB	7&9	12.5Ω	5 ma	950430	SE209A-2		MDL 90CT329-1K (10 db)	Model F101	Filmohm MWB450-HF	Filmohm MWB450-HF	3.5 ma		Coax to WG Adapter 253-1	Bend 950627B	5-1
635AE	7&8	1.05Ω	50 ma	950433	VA173A		MDL WR90 (17 db)	Model F101	Filmohm MWB450-HF	Filmohm MWB450-HF	30 ma	Coax cable 950871C-3 & coax to WG Adapter 253-1	Bend 950627B		5-2
637AB	7&9	12.5Ω	5 ma	950329	SE216-2		MDL 62CT36 (10 db)	Model F102	Narda N604	Narda N604	3.5 ma			Bend 950628B	5-5
637AE	7&8	1.05Ω	50 ma	950330	VA162A		MDL WR-62 (17 db)	Model F102	Narda N604	Narda N604	30 ma	Flexible Waveguide 254-7	Bend 950628B		5-6



SPECIFIED:
OHMS, 1/2W, 10%.
IN MICROFARADS, 500V.

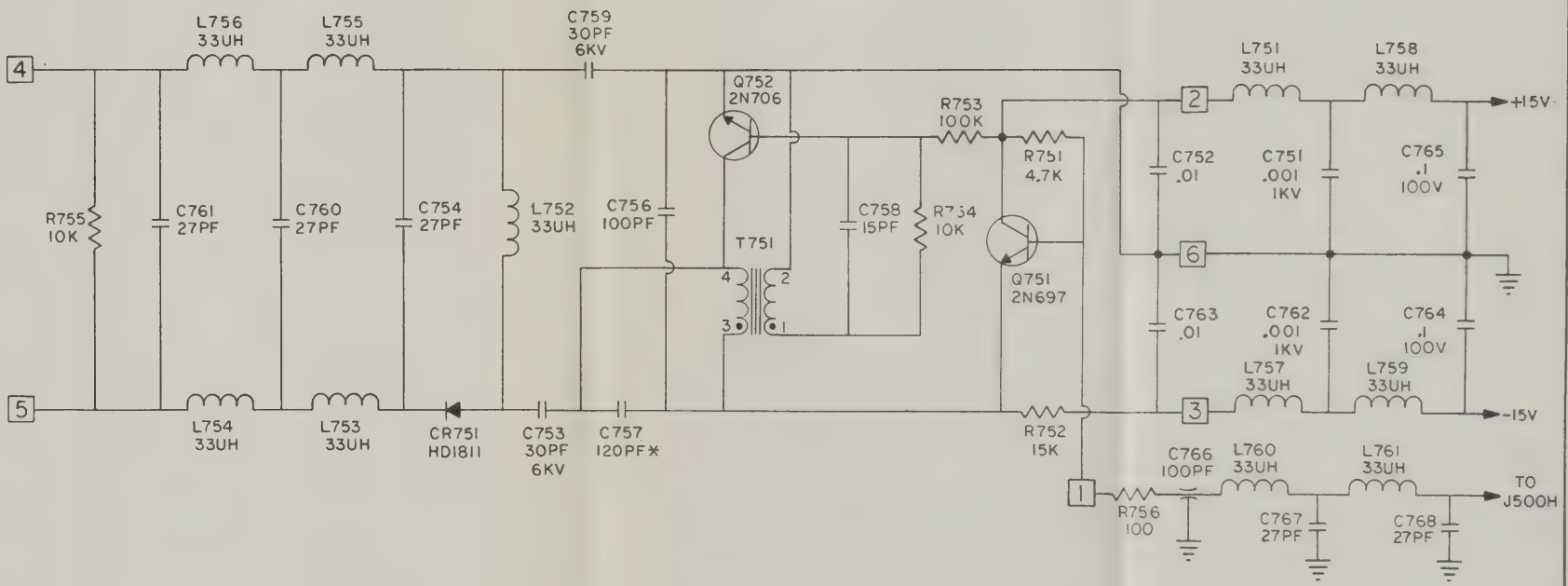
NATES PRINTED WIRING BOARD CONNECTION
7.

SELECTED VALUE.

EMATIC—TRANSFER
OSCILLATOR

900597C

SHEET 1 OF 1



NOTES:

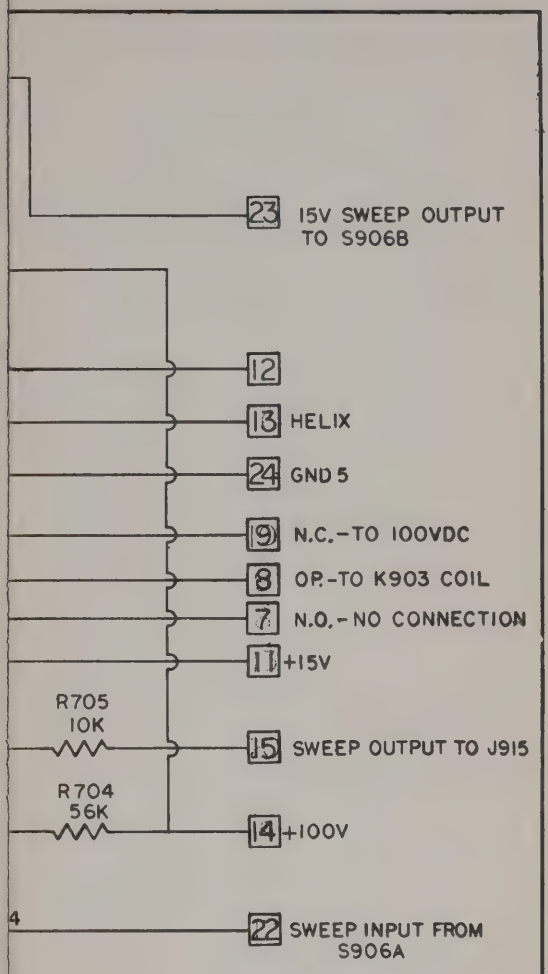
1. UNLESS OTHERWISE SPECIFIED:
   1A. ALL RESISTORS IN OHMS, 1/2W, 10%.
   1B. ALL CAPACITORS IN MICROFARADS, 500V.
2. SQUARE(□) DESIGNATES PRINTED WIRING BOARD CONNECTION ON ASSEMBLY 950277.

* INDICATES FACTORY SELECTED VALUE.

SCHEMATIC – TRANSFER OSCILLATOR

900597C

SHEET 1 OF 1



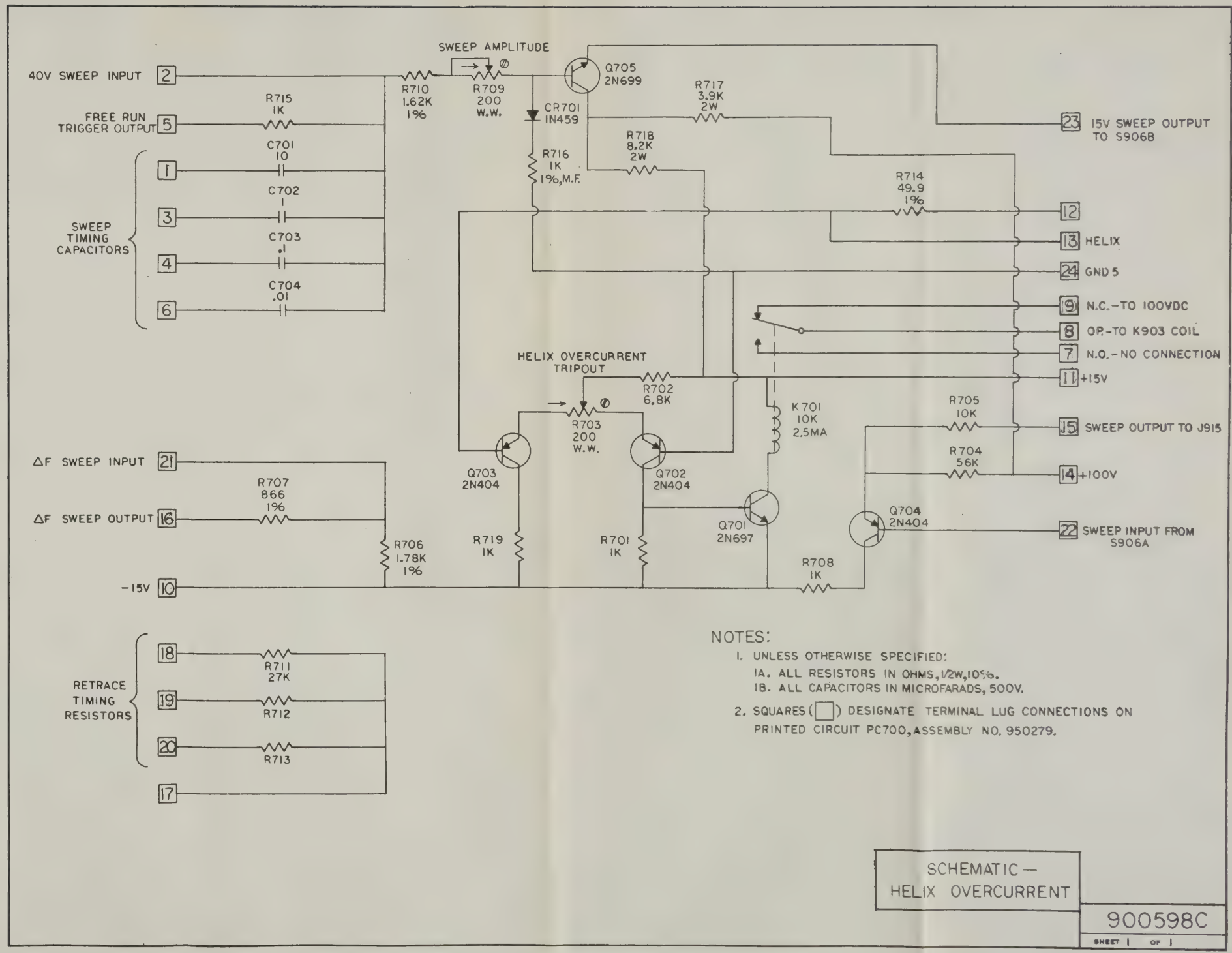
IED:
MS, 1/2W, 10%.
ROFARADS, 500V.

TERMINAL LUG CONNECTIONS ON
SSEMBLY NO. 950279.

SCHEMATIC —
IX OVERCURRENT

900598C

SHEET 1 OF 1



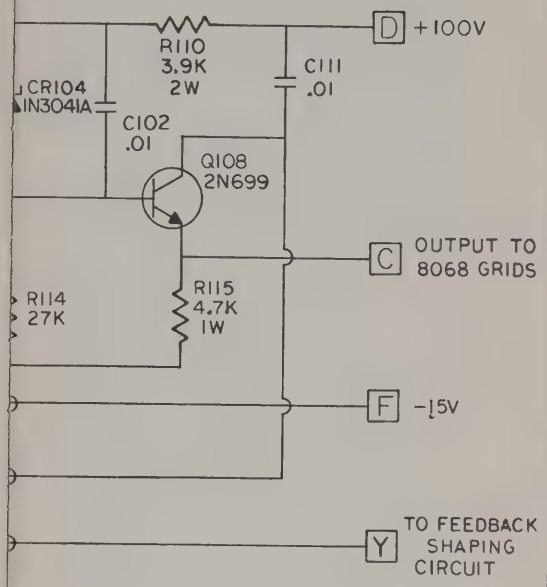
NOTES:

1. UNLESS OTHERWISE SPECIFIED:
   1A. ALL RESISTORS IN OHMS, 1/2W, 10%.
   1B. ALL CAPACITORS IN MICROFARADS, 500V.
2. SQUARES (□) DESIGNATE TERMINAL LUG CONNECTIONS ON PRINTED CIRCUIT PC700, ASSEMBLY NO. 950279.

SCHEMATIC — HELIX OVERCURRENT

900598C

SHEET 1 OF 1



S:

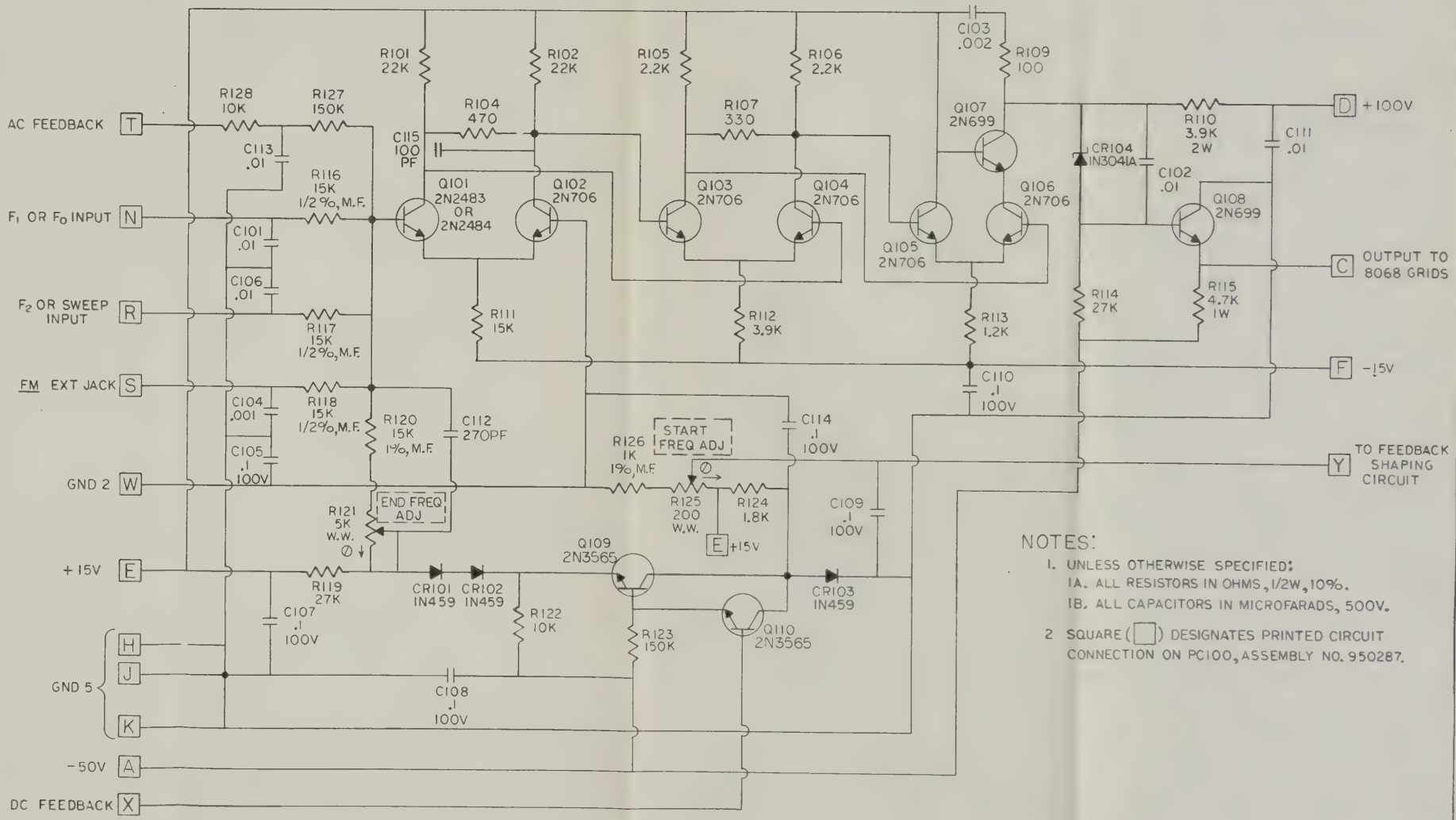
NLESS OTHERWISE SPECIFIED:

. ALL RESISTORS IN OHMS, 1/2W, 10%.

. ALL CAPACITORS IN MICROFARADS, 500V.

QUARE ( ) DESIGNATES PRINTED CIRCUIT
ONNECTION ON PC100, ASSEMBLY NO. 950287.

SCHEMATIC — ATHODE SUPPLY	900599C
	SHEET 1 OF 1



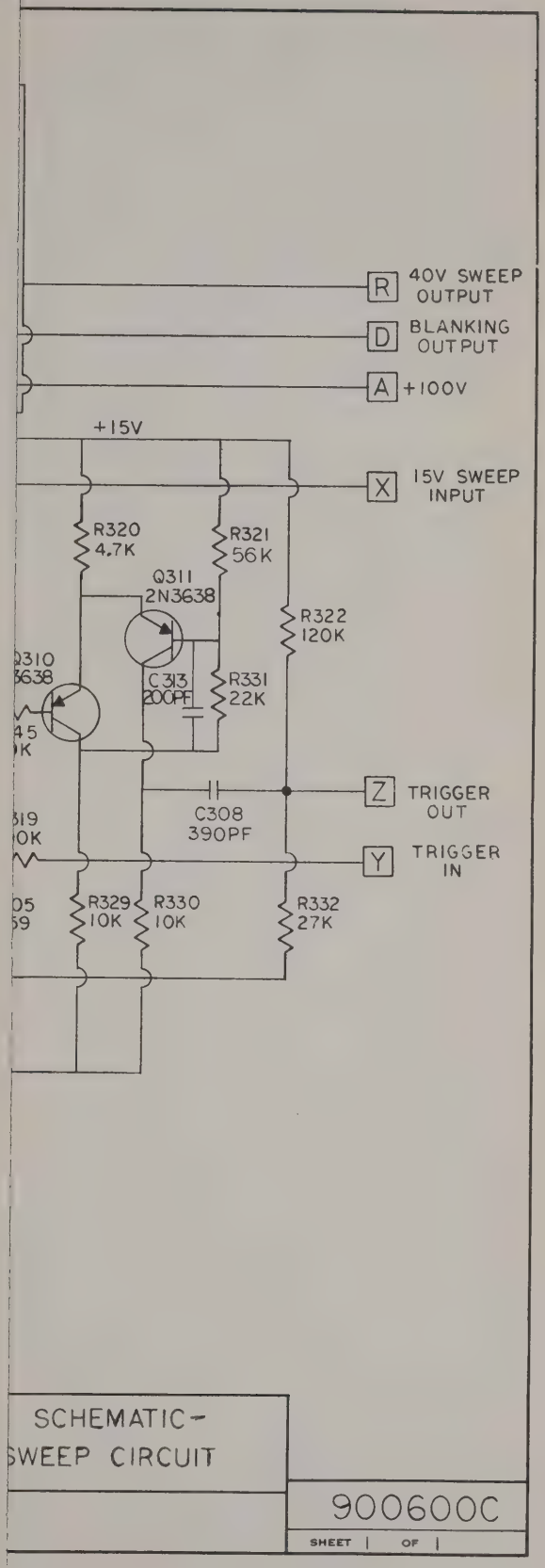
NOTES:

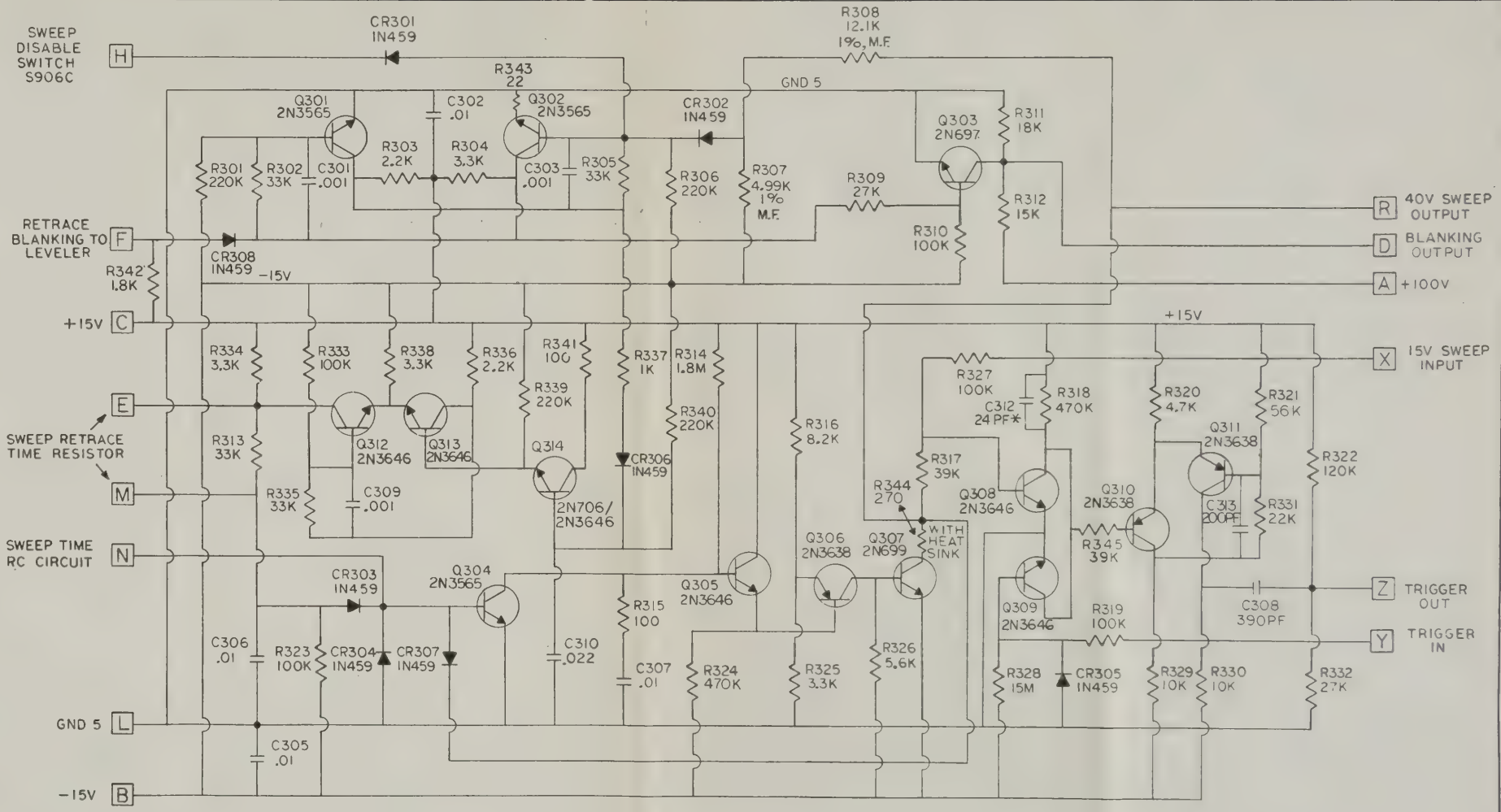
1. UNLESS OTHERWISE SPECIFIED:
   1A. ALL RESISTORS IN OHMS, 1/2W, 10%.
   1B. ALL CAPACITORS IN MICROFARADS, 500V.
2. SQUARE (□) DESIGNATES PRINTED CIRCUIT CONNECTION ON PC100, ASSEMBLY NO. 950287.

SCHEMATIC — CATHODE SUPPLY

900599C

SHEET 1 OF 1


R 40V SWEEP OUTPUT
D BLANKING OUTPUT
A +100V
+15V
X 15V SWEEP INPUT
R320 4.7K
R321 56K
Q311 2N3638
R322 120K
C313 200PF
R331 22K
C308 390PF
Z TRIGGER OUT
Y TRIGGER IN
R329 10K
R330 10K
R332 27K
SCHEMATIC-
SWEEP CIRCUIT
900600C
SHEET 1 OF 1



NOTES:

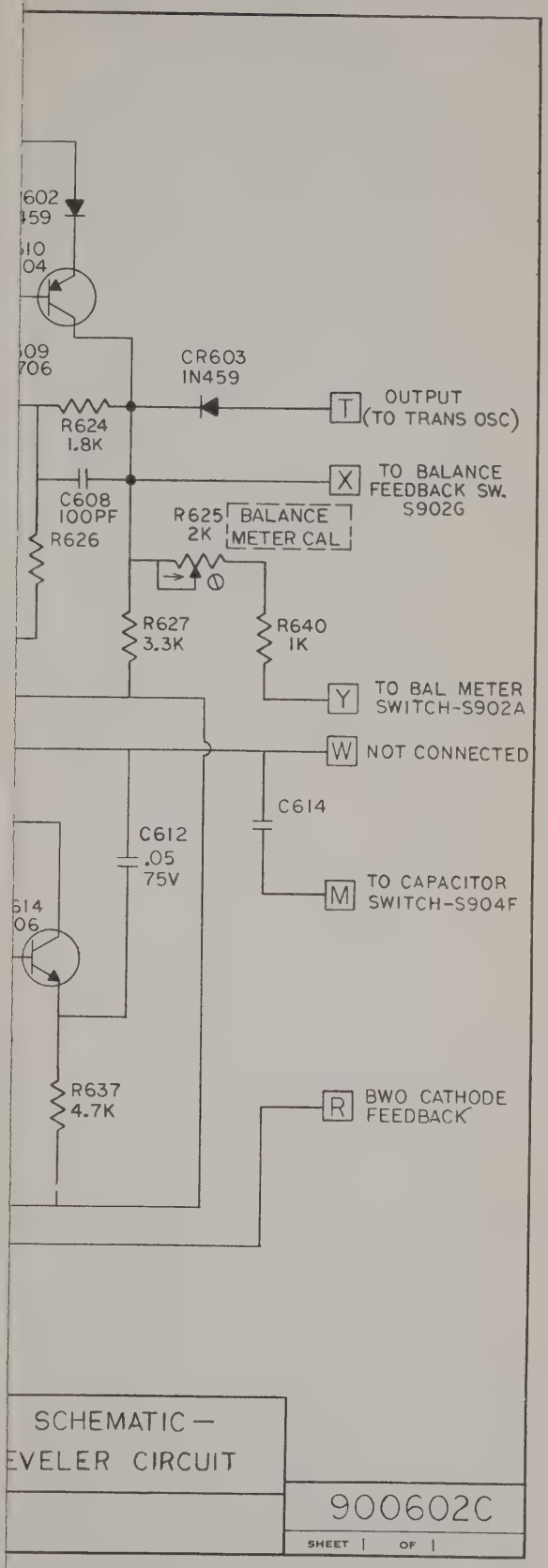
1. UNLESS OTHERWISE SPECIFIED
   - 1A. ALL RESISTORS IN OHMS, 1/2W, 10%.
   - 1B. ALL CAPACITORS IN MICROFARADS, 500V.
2. SQUARE (□) DESIGNATES PRINTED CIRCUIT CONNECTION ON PC300, ASSEMBLY NO. 950276.

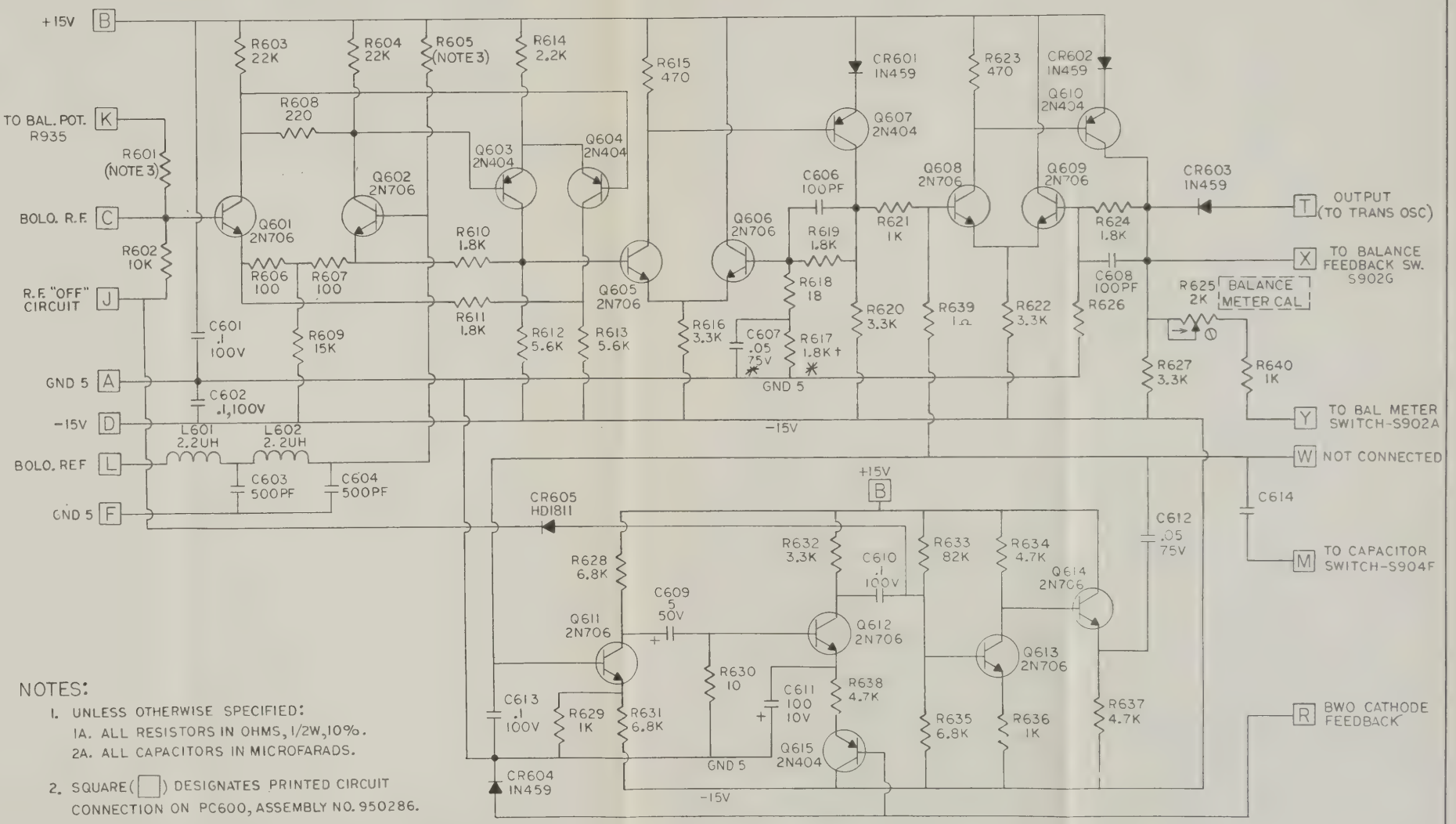
* FACTORY SELECTED

SCHEMATIC- SWEEP CIRCUIT

900600C

SHEET 1 OF 1


602
459
610
704
609
706
CR603
IN459
T
OUTPUT
(TO TRANS OSC)
R624
1.8K
X
TO BALANCE
FEEDBACK SW.
S902G
C608
100PF
R625
2K
BALANCE
METER CAL
R626
R627
3.3K
R640
1K
Y
TO BAL METER
SWITCH-S902A
W
NOT CONNECTED
C614
C612
.05
75V
M
TO CAPACITOR
SWITCH-S904F
614
606
R637
4.7K
R
BWO CATHODE
FEEDBACK
SCHEMATIC —
EVELER CIRCUIT
900602C
SHEET 1 OF 1



NOTES:

1. UNLESS OTHERWISE SPECIFIED:
   1A. ALL RESISTORS IN OHMS, 1/2W, 10%.
   2A. ALL CAPACITORS IN MICROFARADS.
2. SQUARE(□) DESIGNATES PRINTED CIRCUIT CONNECTION ON PC600, ASSEMBLY NO. 950286.
3. FOR 4.5MA BARRETTERS--R601, 2.61K, 1%-R605, 3.16K, 1%.
   FOR 8.75MA BARRETTERS--R601, 1.47K, 1%-R605, 1.58K, 1%.

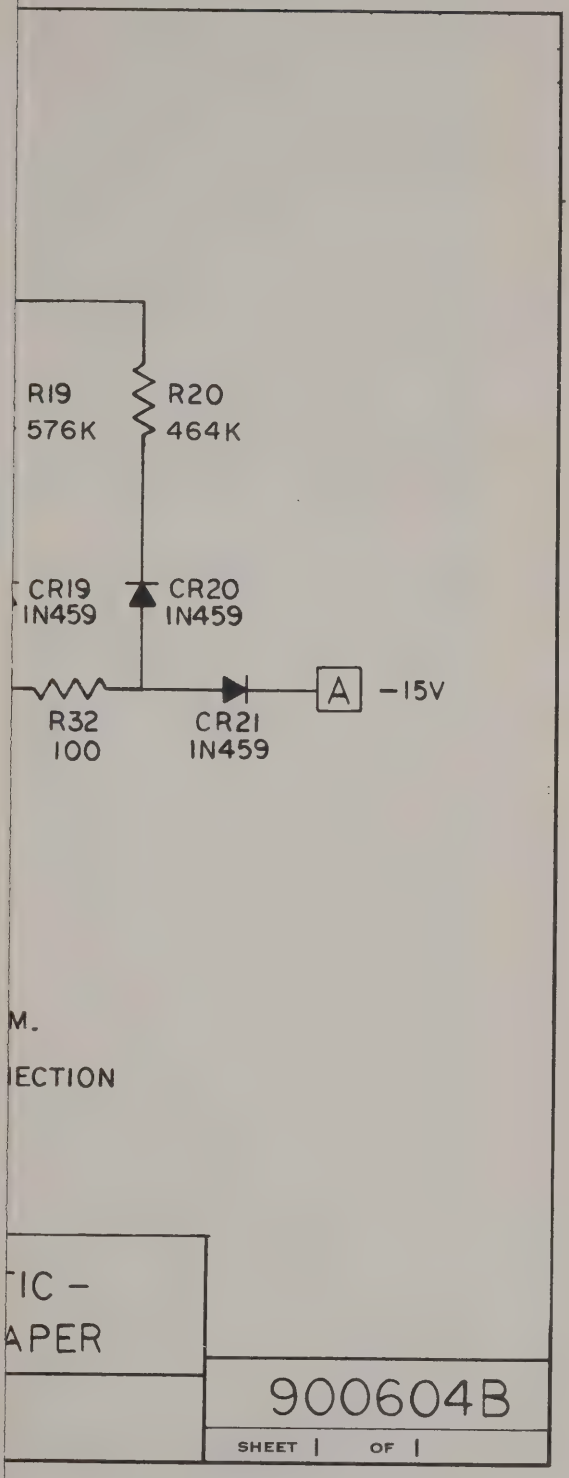
† FOR MODEL 637 BOTTOM END OF R617 CONNECTS TO TOP OF R613 INSTEAD OF TO GROUND.

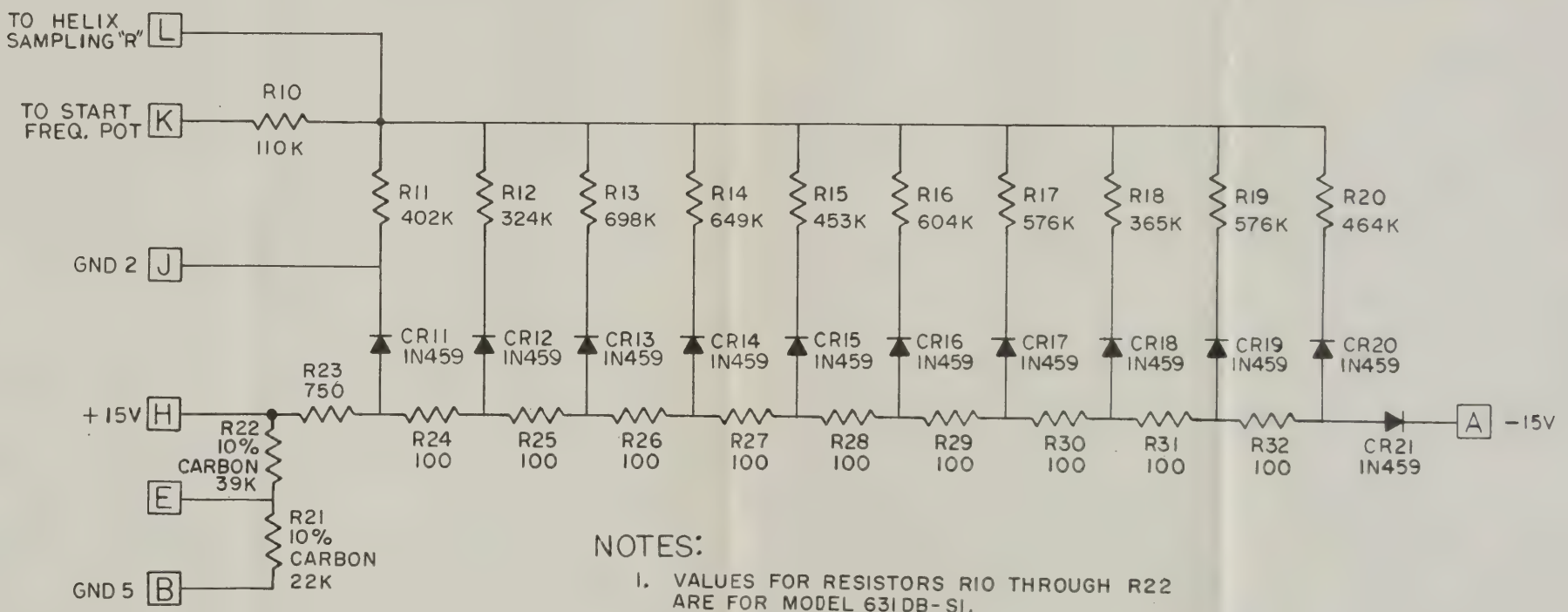
* FACTORY SELECTED

SCHEMATIC — LEVELER CIRCUIT

900602C

SHEET 1 OF 1


R19
576K
R20
464K
CR19
IN459
CR20
IN459
A
-15V
R32
100
CR21
IN459
M.
IECTION
TIC -
APER
900604B
SHEET 1 OF 1



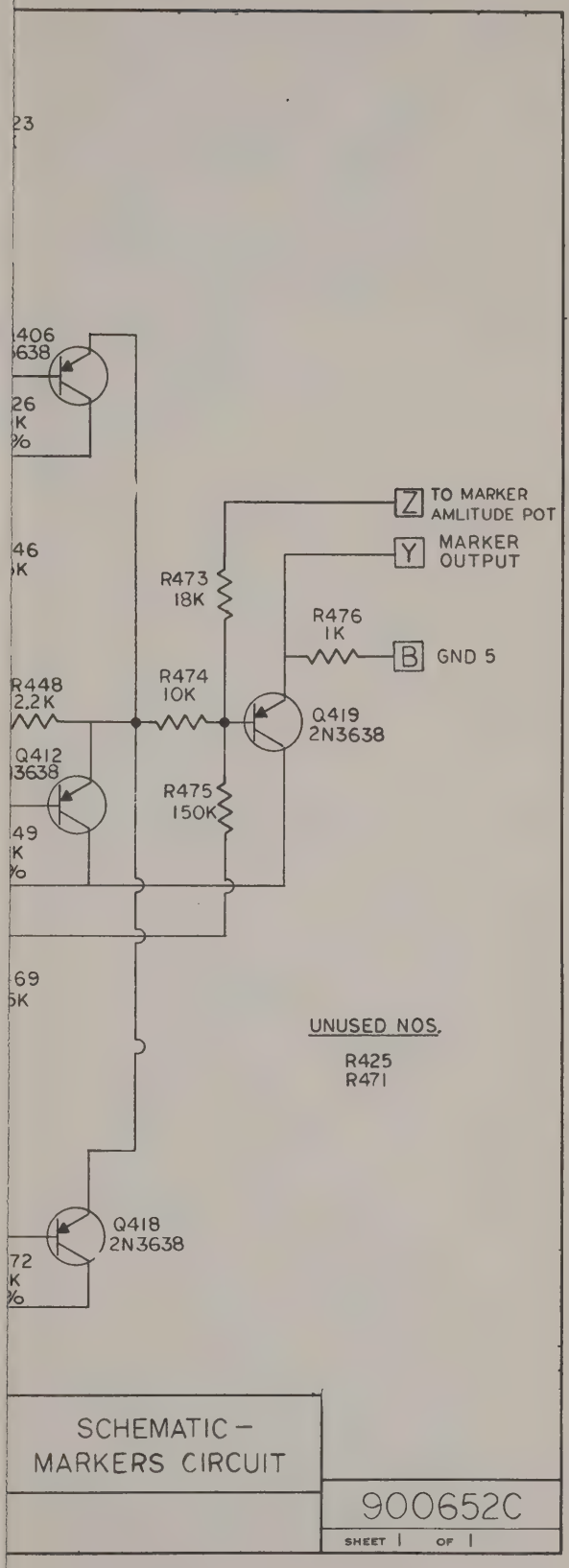
NOTES:

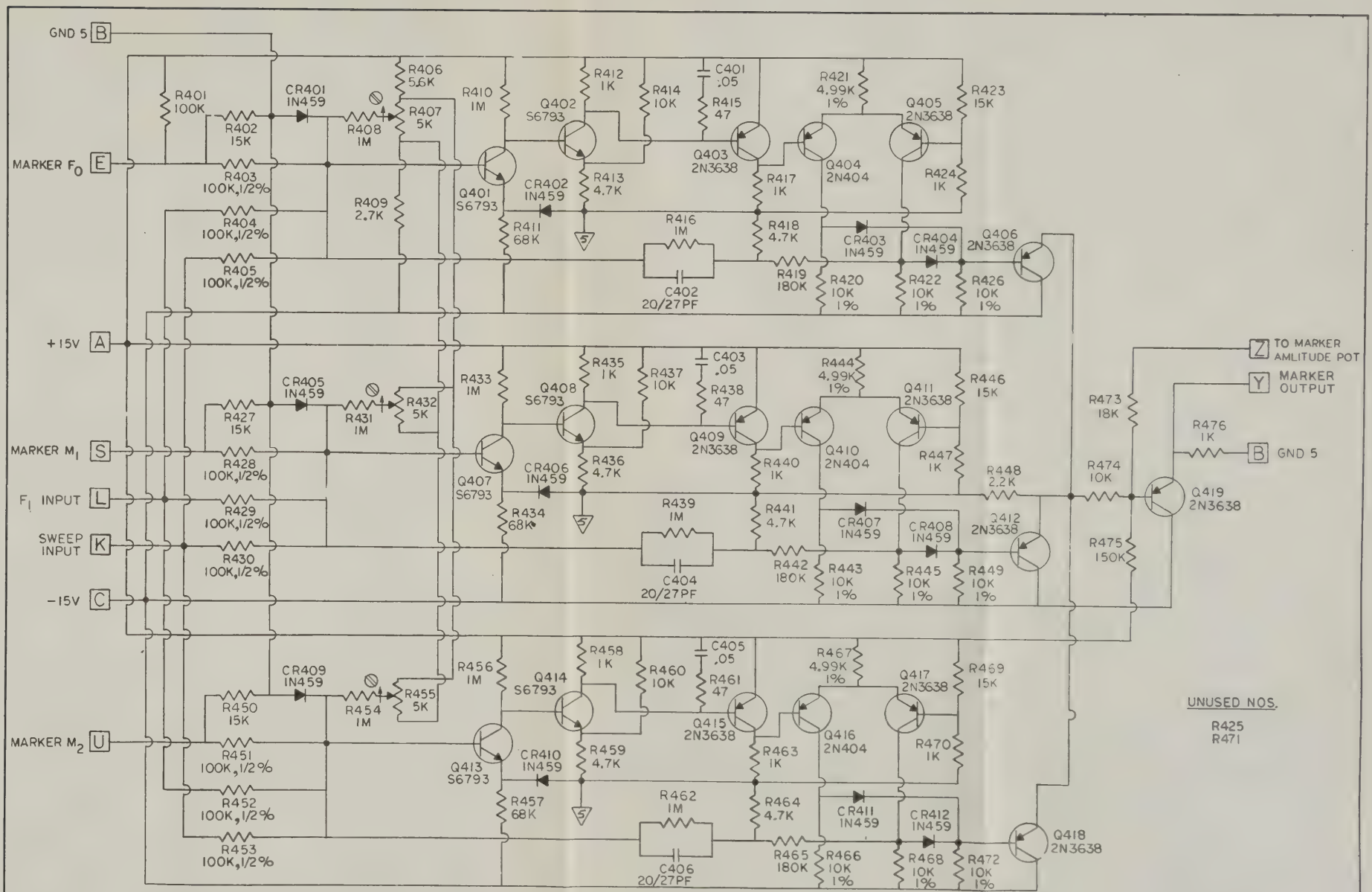
1. VALUES FOR RESISTORS R10 THROUGH R22 ARE FOR MODEL 631DB-S1.
2. UNLESS OTHERWISE SPECIFIED:
   2A. ALL RESISTORS IN OHMS, 1/2W, 1%, METAL FILM.
3. SQUARE (□) DESIGNATES PRINTED CIRCUIT CONNECTION ON PC900.

SCHEMATIC – DIODE SHAPER

900604B

SHEET 1 OF 1


Z TO MARKER AMLITUDE POT
Y MARKER OUTPUT
B GND 5
R473 18K
R476 1K
R474 10K
R475 150K
R448 2.2K
Q419 2N3638
Q412 3638
Q418 2N3638
UNUSED NOS.
R425
R471
SCHEMATIC – MARKERS CIRCUIT
900652C
SHEET 1 OF 1



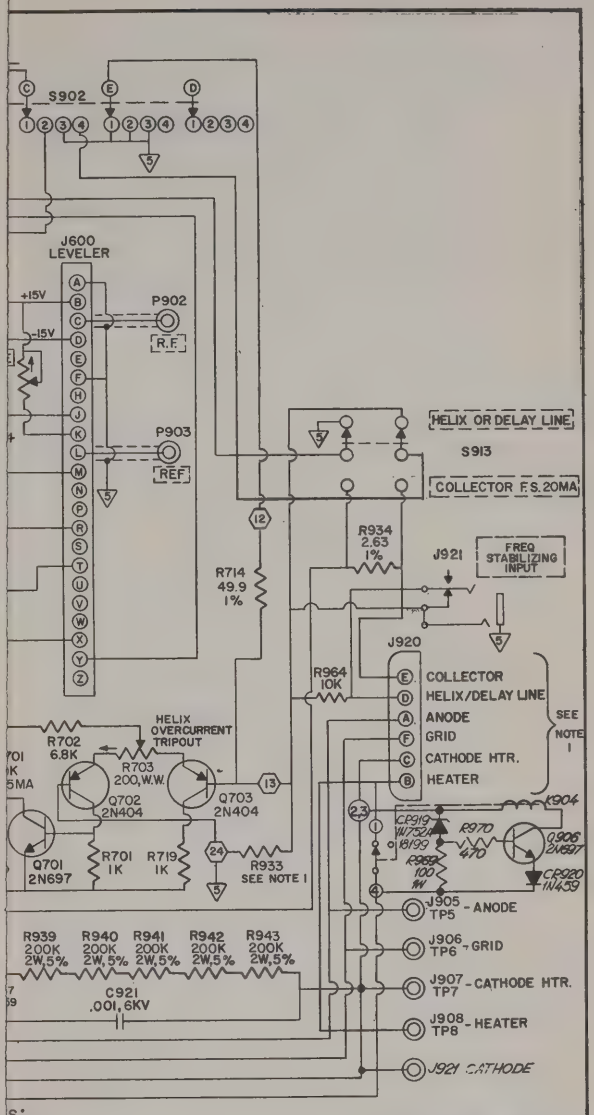
NOTES:

1. UNLESS OTHERWISE SPECIFIED:
   1A. ALL RESISTORS IN OHMS, 1/2W, 10%.
   1B. ALL 1/2% AND 1% RESISTORS ARE METAL FILM TYPE.
   1C. ALL CAPACITORS IN MICROFARADS, 500V.
2. SQUARE (□) DESIGNATES PRINTED CIRCUIT CONNECTION ON PC400, ASSEMBLY NO. 950369.
3. ON MODEL 640, S/N 11-119, R427 & R450 ARE 39K.

SCHEMATIC – MARKERS CIRCUIT

900652C

SHEET 1 OF 1



S:

REFER TO INSTRUCTION MANUAL FOR SPECIFIC VALUE OR CIRCUIT FOR THE PARTICULAR MODEL INVOLVED.

(REMOTE FREQUENCY TERMINAL BOARD)- REFER TO INSTRUCTION MANUAL FOR DETAILED INSTRUCTIONS FOR REMOTE FREQUENCY OPERATION.

UNLESS OTHERWISE SPECIFIED:
3A. ALL RESISTORS IN OHMS, 1/2W. 10%.
3B. ALL CAPACITORS IN MICROFARADS, 500V.
3C. ALL ROTARY SWITCHES SHOWN IN CCW POSITION
3D. ALL RELAYS SHOWN IN DE-ENERGIZED POSITION.
3E. ARROWS ON ALL POTS INDICATE CW ADJUSTMENT.
3F ALL VOLTAGES RELATIVE TO GROUND.
R935 IS 250Ω FOR THE MODEL 637

TRIANGLE (▽) INDICATES GROUND CONNECTION.

HEXAGON (⬡) INDICATES TERMINAL CONNECTION ON HELIX OVERCURRENT PRINTED CIRCUIT BOARD.

SQUARE (□) INDICATES TERMINAL CONNECTION ON TRANSFER OSCILLATOR PRINTED CIRCUIT BOARD.

CIRCLE (○) INDICATES TERMINAL TO HEATER OVERVOLTAGE BOARD.

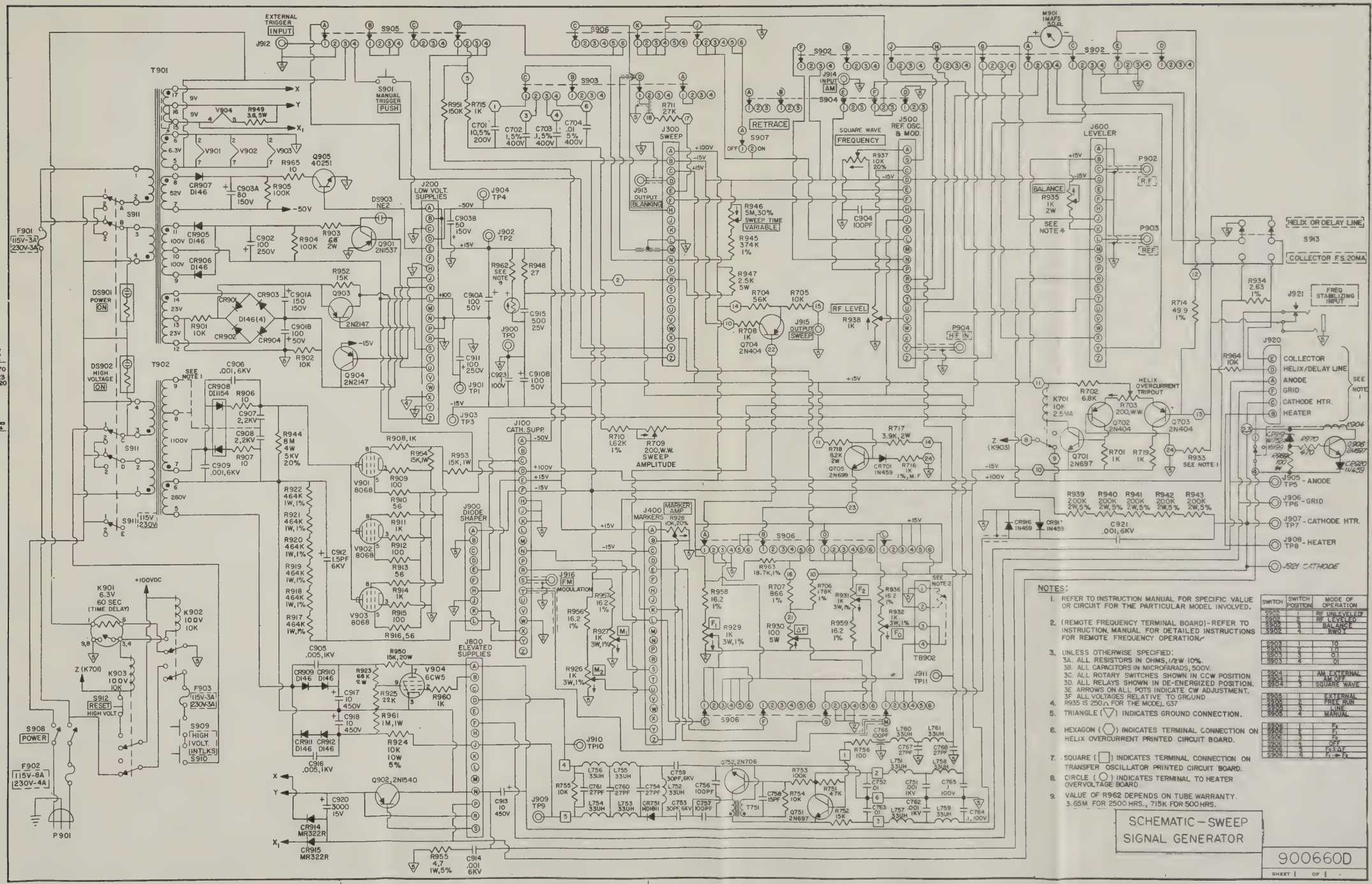
VALUE OF R962 DEPENDS ON TUBE WARRANTY. 3.65M FOR 2500 HRS., 715K FOR 500 HRS.

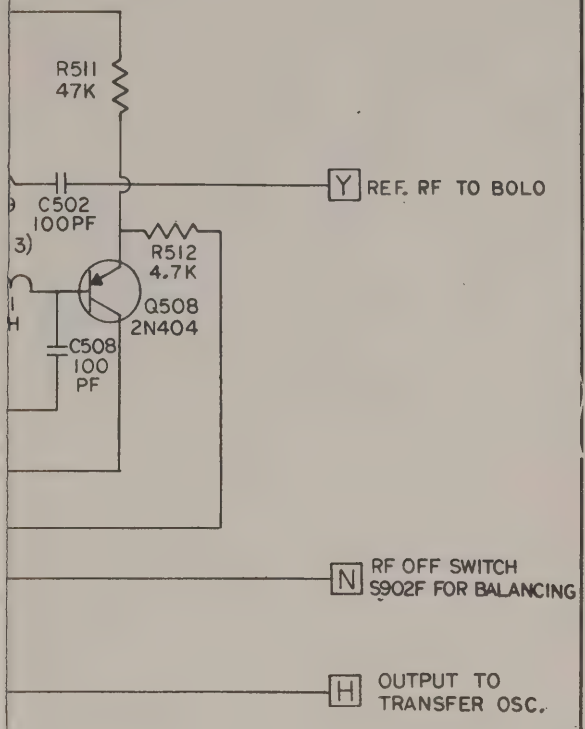
SWITCH	SWITCH POSITION	MODE OF OPERATION
S902	1	RF UNLEVELED
S902	2	RF LEVELED
S902	3	BALANCE
S902	4	BWO X
S903	1	10
S903	2	1.0
S903	3	0.1
S903	4	.01
S904	1	AM EXTERNAL
S904	2	AM OFF
S904	3	SQUARE WAVE
S905	1	EXTERNAL
S905	2	FREE RUN
S905	3	LINE
S905	4	MANUAL
S906	1	F_R
S906	2	F_1
S906	3	F_0
S906	4	OFF
S906	5	$F_0 \pm \Delta F$
S906	6	$F_1 \rightarrow F_0$

SCHEMATIC – SWEEP SIGNAL GENERATOR

900660D

SHEET 1 OF 1


EXTERNAL TRIGGER INPUT
J912
S901 MANUAL TRIGGER PUSH
T901
T902
F901 115V-3A 230V-3A
F902 115V-8A 230V-4A
F903 115V-3A 230V-3A
P901
S908 POWER
S909 HIGH VOLT. INTLKS
S910
S911
S912 RESET HIGH VOLT
DS901 POWER ON
DS902 HIGH VOLTAGE ON
DS903 NE2
Q901 2N1537
Q902 2N1540
Q903 2N2147
Q904 2N2147
Q905 40251
V901 V902 V903 V904 V901 V902 V903 V904 8068 6CW5
K901 6.3V 60 SEC (TIME DELAY)
K902 100V 10K
K903 100V 10K
+100VDC
J200 LOW VOLT. SUPPLIES
J800 ELEVATED SUPPLIES
J100 CATH. SUPP.
J900 DIODE SHAPER
J300 SWEEP
J400 MARKERS
MARKER AMP
J500 REF. OSC. & MOD.
J600 LEVELER
J900 TP0
J901 TP1
J902 TP2
J903 TP3
J904 TP4
J909 TP9
J910 TP10
J911 TP11
J913 OUTPUT BLANKING
J914 INPUT AM
J915 OUTPUT SWEEP
J916 FM MODULATION
J920
J921 FREQ STABILIZING INPUT
P902 R.F.
P903 REF.
P904 H.F. IN
TB902
S901 S902 S903 S904 S905 S906 S907
RETRACE
SQUARE WAVE FREQUENCY
RF LEVEL
BALANCE
SEE NOTE 4
HELIX OVERCURRENT TRIPOUT
HELIX OR DELAY LINE
S913
COLLECTOR FS 20MA
J920 COLLECTOR
HELIX/DELAY LINE
ANODE
GRID
CATHODE HTR.
HEATER
J905 - ANODE
J906 - GRID
J907 - CATHODE HTR.
J908 - HEATER
J921 - CATHODE
SEE NOTE 1
SEE NOTE 2
R908,1K
R909 100
R910 56
R911 1K
R912 100
R913 56
R914 1K
R915 100
R916,56
R922 464K 1W,1%
R921 464K 1W,1%
R920 464K 1W,1%
R919 464K 1W,1%
R918 464K 1W,1%
R917 464K 1W,1%
R944 8M 4W 5KV 20%
R945 374K 1%
R946 5M,30% SWEEP TIME VARIABLE
R947 2.5K 5W
R948 27
R949 3.8,5W
R950 15K,20W
R951 150K
R952 15K
R953 15K,1W
R954 15K,1W
R955 4.7 1W,5%
R956 16.2 1%
R957 16.2 1%
R958 16.2 1%
R959 16.2 1%
R960 1K
R961 1M,1W
R962 SEE NOTE 5
R963 18.7K,1%
R964 10K
R965 10
R966 10
R967 10
R969 100 5W
R970 4.7Ω
R971 100 5W
R901 10K
R902 10K
R903 68 2W
R904 100K
R905 100K
R906 10
R907 10
R908 10K,20%
R926 1K 3W,1%
R927 1K 3W,1%
R928 10K,20%
R929 1K 3W,1%
R930 100 5W
R931 1K 3W,1%
R932 1K 3W,1%
R933 SEE NOTE 1
R934 2.63 1%
R935 1K 2W
R936 16.2 1%
R937 10K 20%
R938 1K
R939 200K 2W,5%
R940 200K 2W,5%
R941 200K 2W,5%
R942 200K 2W,5%
R943 200K 2W,5%
R945 374K 1%
R946 5M,30% SWEEP TIME VARIABLE
R947 2.5K 5W
R948 27
R949 3.8,5W
R950 15K,20W
R951 150K
R952 15K
R953 15K,1W
R954 15K,1W
R955 4.7 1W,5%
R956 16.2 1%
R957 16.2 1%
R958 16.2 1%
R959 16.2 1%
R960 1K
R961 1M,1W
R962 SEE NOTE 5
R963 18.7K,1%
R964 10K
R965 10
R966 10
R967 10
R969 100 5W
R970 4.7Ω
R971 100 5W
R901 10K
R902 10K
R903 68 2W
R904 100K
R905 100K
R906 10
R907 10
R908 10K,20%
R926 1K 3W,1%
R927 1K 3W,1%
R928 10K,20%
R929 1K 3W,1%
R930 100 5W
R931 1K 3W,1%
R932 1K 3W,1%
R933 SEE NOTE 1
R934 2.63 1%
R935 1K 2W
R936 16.2 1%
R937 10K 20%
R938 1K
R939 200K 2W,5%
R940 200K 2W,5%
R941 200K 2W,5%
R942 200K 2W,5%
R943 200K 2W,5%
C901A 150 150V
C901B 100 50V
C902 100 250V
C903A 80 150V
C903B 50 150V
C904 100PF
C905 .005,1KV
C906 .001,6KV
C907 2.2KV
C908 2.2KV
C909 .001,6KV
C910A 100 50V
C910B 100 50V
C911 100 250V
C912 1.5PF 6KV
C913 10 450V
C914 .001 6KV
C915 500 25V
C916 .005,1KV
C917 10 450V
C918 10 450V
C920 3000 15V
C921 .001,6KV
C923 100V
C701 10,5% 200V
C702 1,5% 400V
C703 1,5% 400V
C704 .01 5% 400V
R701 1K
R702 6.8K
R703 200,WW
R704 56K
R705 10K
R706 178K 1%
R707 866 1%
R708 1K
R709 200,W.W. SWEEP AMPLITUDE
R710 1.62K 1%
R711 27K
R712 100
R714 49.9 1%
R715 1K
R716 1K 1%,M.F.
R717 3.9K,2W
R718 82K 2W
R719 1K
CR901 CR902 CR903 CR904 D146(4)
CR905 D146
CR906 D146
CR907 D146
CR908 D11154
CR909 D146
CR910 D146
CR911 D146
CR912 D146
CR914 MR322R
CR915 MR322R
CR916 1N459
CR917 1N459
CR701 1N459
Q700 2N699
Q701 2N697
Q702 2N404
Q703 2N404
Q704 2N404
Q705 2N699
Q751 2N697
Q752,2N706
T751
L754 33UH
L755 33UH
L756 33UH
L753 33UH
L752 33UH
L757 33UH
L758 33UH
L759 33UH
L760 33UH
L761 33UH
C752 .01
C753 .01
C754 27PF
C755 .001 1KV
C756 100PF
C757 100PF
C758 15PF
C759 30PF,6KV
C760 27PF
C761 27PF
C762 .001 1KV
C763 .01
C764 1, 100V
C765 100V
C766 100PF
C767 27PF
C768 27PF
CR751 HD1811
CR752 HD1811
R751 47K
R752 15K
R753 100K
R754 10K
R755 10K
R756 100
K701 10K 2.5MA
Z (K903)
Z (K701)
F1
F2
ΔF
M1
M2
F0
NOTES:
1. REFER TO INSTRUCTION MANUAL FOR SPECIFIC VALUE OR CIRCUIT FOR THE PARTICULAR MODEL INVOLVED.
2. (REMOTE FREQUENCY TERMINAL BOARD)-REFER TO INSTRUCTION MANUAL FOR DETAILED INSTRUCTIONS FOR REMOTE FREQUENCY OPERATION.
3. UNLESS OTHERWISE SPECIFIED:
3A. ALL RESISTORS IN OHMS, 1/2W 10%.
3B. ALL CAPACITORS IN MICROFARADS, 500V.
3C. ALL ROTARY SWITCHES SHOWN IN CCW POSITION
3D. ALL RELAYS SHOWN IN DE-ENERGIZED POSITION.
3E ARROWS ON ALL POTS INDICATE CW ADJUSTMENT.
3F ALL VOLTAGES RELATIVE TO GROUND
4. R935 IS 250Ω FOR THE MODEL 637
5. TRIANGLE (▽) INDICATES GROUND CONNECTION.
6. HEXAGON (⬡) INDICATES TERMINAL CONNECTION ON HELIX OVERCURRENT PRINTED CIRCUIT BOARD.
7. SQUARE (□) INDICATES TERMINAL CONNECTION ON TRANSFER OSCILLATOR PRINTED CIRCUIT BOARD.
8. CIRCLE (○) INDICATES TERMINAL TO HEATER OVERVOLTAGE BOARD.
9. VALUE OF R962 DEPENDS ON TUBE WARRANTY. 3.65M FOR 2500 HRS., 715K FOR 500 HRS.
SWITCH | SWITCH POSITION | MODE OF OPERATION
S902 1 RF UNLEVELED
S902 2 RF LEVELED
S902 3 BAL ADJ
S902 4 RWDT
S903 1 10
S903 2 1.0
S903 3 0.1
S903 4 01
S904 1 AM EXTERNAL
S904 2 AM OFF
S904 3 SQUARE WAVE
S905 1 EXTERNAL
S905 2 FREE RUN
S905 3 LINE
S905 4 MANUAL
S906 1 F4
S906 2 F3
S906 3 F2
S906 4 OFF
S906 5 F1 ΔF
S906 6 F1 = F4
SCHEMATIC – SWEEP SIGNAL GENERATOR
900660D
SHEET 1 OF 1



NLESS OTHERWISE SPECIFIED:

. ALL RESISTORS IN OHMS, 1/2W, 10%.

. ALL CAPACITORS IN MICROFARADS, 500V.

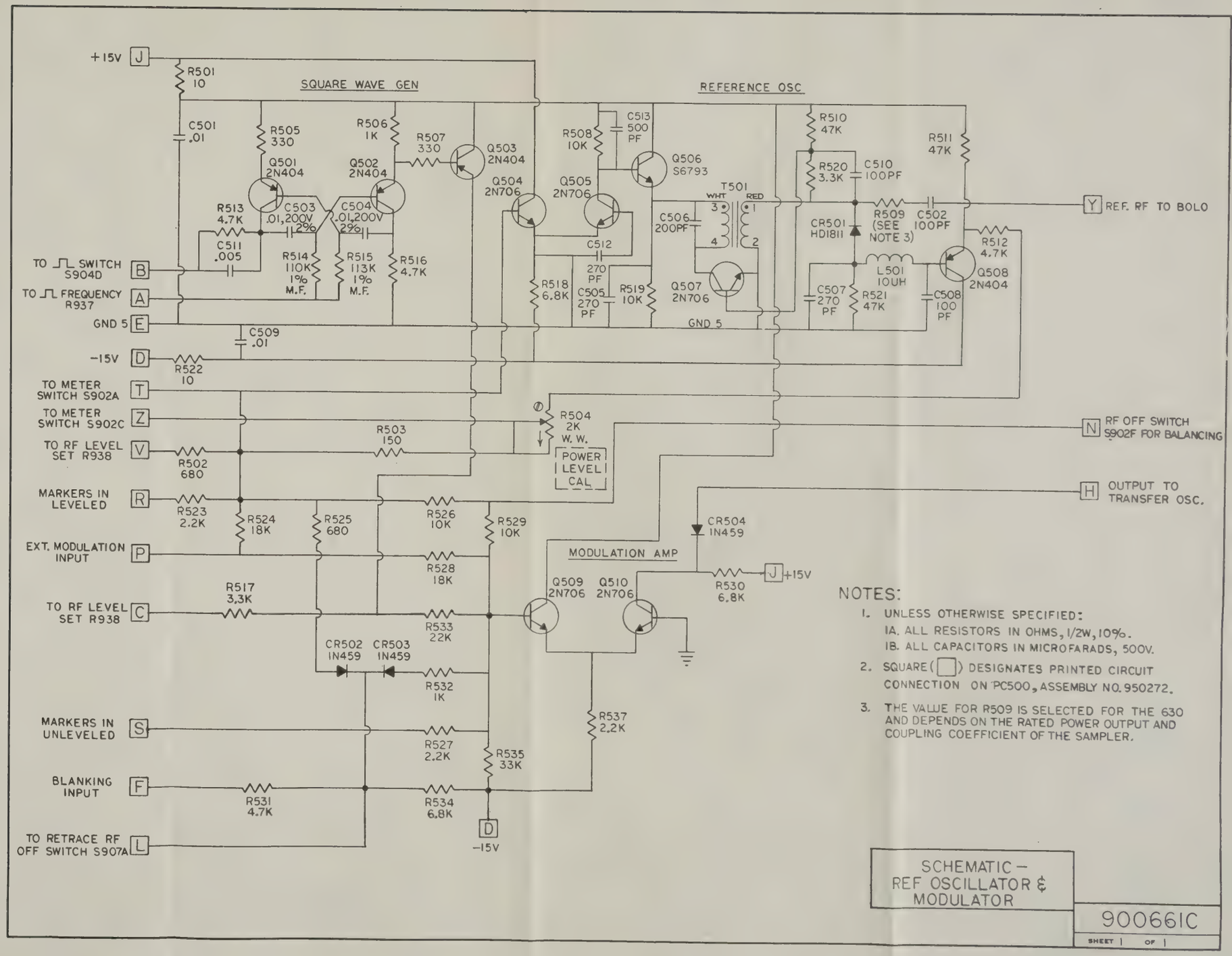
QUARE( ) DESIGNATES PRINTED CIRCUIT
ONNECTION ON PC500, ASSEMBLY NO. 950272.

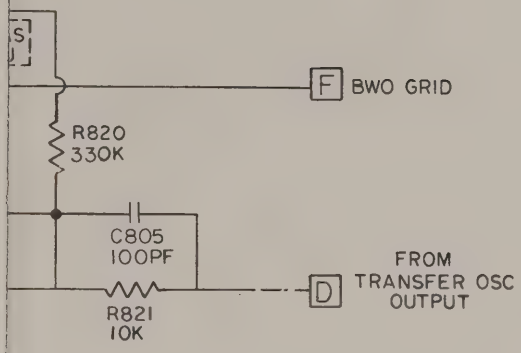
HE VALUE FOR R509 IS SELECTED FOR THE 630
ND DEPENDS ON THE RATED POWER OUTPUT AND
OUPLING COEFFICIENT OF THE SAMPLER.

SCHEMATIC –
REF OSCILLATOR &
MODULATOR

90066IC

SHEET 1 OF 1


+15V J
R501 10
SQUARE WAVE GEN
REFERENCE OSC
C501 .01
R505 330
R506 1K
R507 330
Q501 2N404
Q502 2N404
Q503 2N404
Q504 2N706
R513 4.7K
C503 .01,200V 2%
C504 .01,200V 2%
C511 .005
R514 110K 1% M.F.
R515 113K 1% M.F.
R516 4.7K
TO SWITCH S904D B
TO FREQUENCY R937 A
GND 5 E
C509 .01
-15V D
R522 10
TO METER SWITCH S902A T
TO METER SWITCH S902C Z
TO RF LEVEL SET R938 V
R502 680
R503 150
R504 2K W.W.
POWER LEVEL CAL
MARKERS IN LEVELED R
R523 2.2K
R524 18K
R525 680
R526 10K
R529 10K
EXT. MODULATION INPUT P
R528 18K
TO RF LEVEL SET R938 C
R517 3.3K
R533 22K
CR502 1N459
CR503 1N459
R532 1K
MARKERS IN UNLEVELED S
R527 2.2K
R535 33K
R537 2.2K
BLANKING INPUT F
R531 4.7K
R534 6.8K
D -15V
TO RETRACE RF OFF SWITCH S907A L
R508 10K
C513 500 PF
Q506 S6793
Q505 2N706
T501
WHT
RED
C506 200PF
C512 270 PF
C505 270 PF
R518 6.8K
R519 10K
Q507 2N706
GND 5
R510 47K
R511 47K
R520 3.3K
C510 100PF
CR501 HD1811
R509 (SEE NOTE 3)
C502 100PF
Y REF. RF TO BOLO
R512 4.7K
Q508 2N404
L501 10UH
C507 270 PF
R521 47K
C508 100 PF
N RF OFF SWITCH S902F FOR BALANCING
H OUTPUT TO TRANSFER OSC.
CR504 1N459
MODULATION AMP
Q509 2N706
Q510 2N706
J +15V
R530 6.8K
NOTES:
1. UNLESS OTHERWISE SPECIFIED:
1A. ALL RESISTORS IN OHMS, 1/2W, 10%.
1B. ALL CAPACITORS IN MICROFARADS, 500V.
2. SQUARE ( ) DESIGNATES PRINTED CIRCUIT CONNECTION ON PC500, ASSEMBLY NO. 950272.
3. THE VALUE FOR R509 IS SELECTED FOR THE 630 AND DEPENDS ON THE RATED POWER OUTPUT AND COUPLING COEFFICIENT OF THE SAMPLER.
SCHEMATIC – REF OSCILLATOR & MODULATOR
900661C
SHEET 1 OF 1



OTHERWISE SPECIFIED:
RESISTORS IN OHMS 1/2W, 10%.
CAPACITORS IN MICROFARADS, 500V.

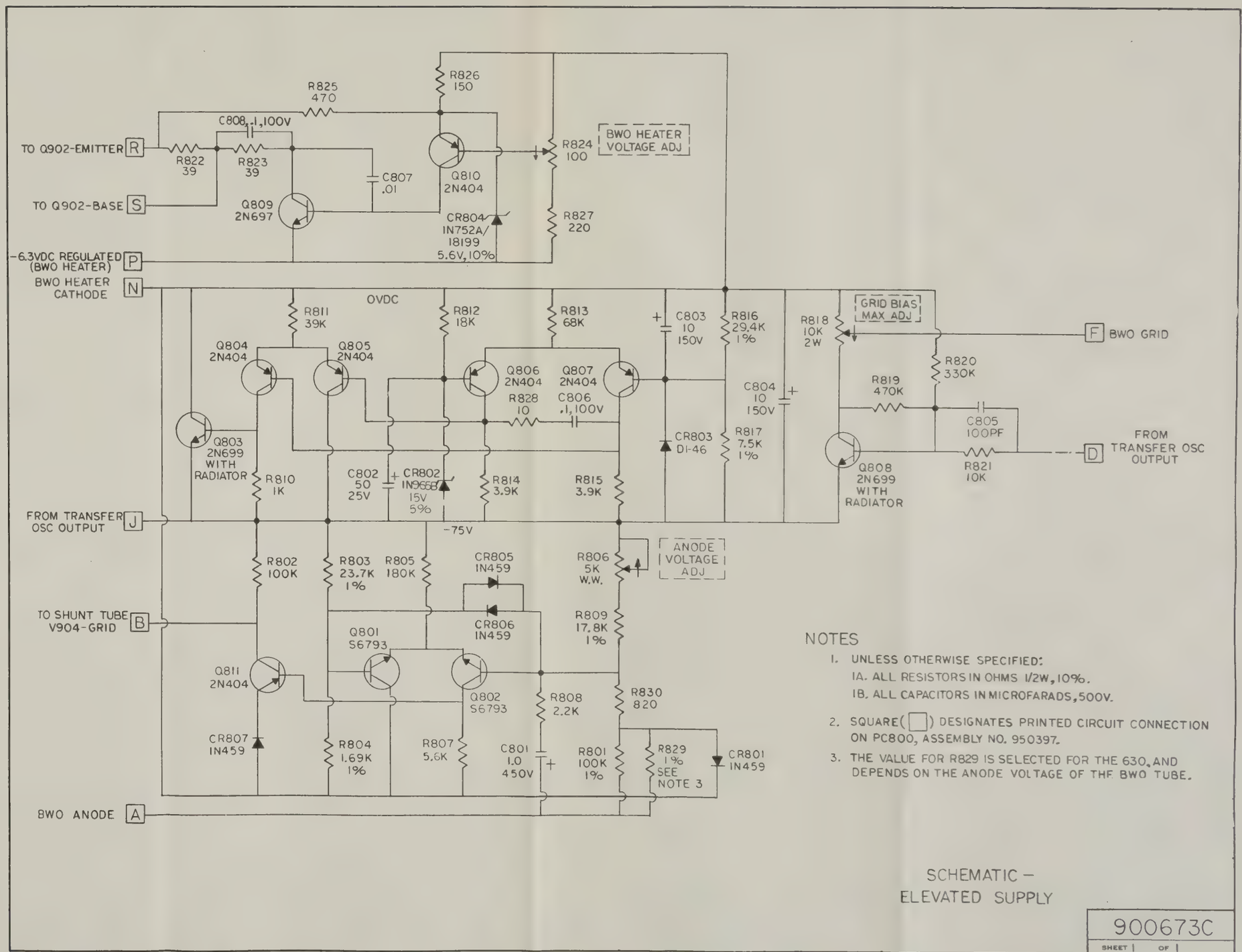
) DESIGNATES PRINTED CIRCUIT CONNECTION
O, ASSEMBLY NO. 950397.

UE FOR R829 IS SELECTED FOR THE 630, AND
S ON THE ANODE VOLTAGE OF THE BWO TUBE.

SCHEMATIC –
ELEVATED SUPPLY

900673C

SHEET 1 OF 1



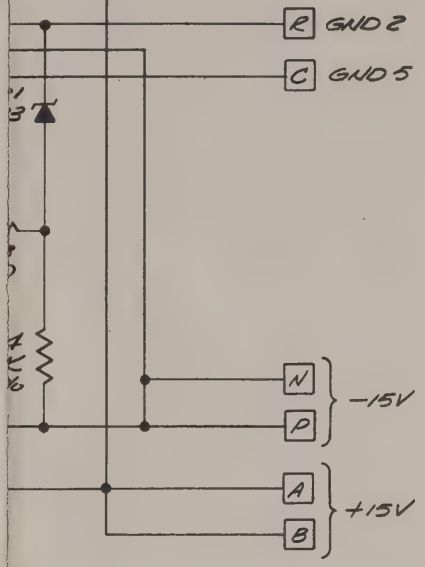
NOTES

1. UNLESS OTHERWISE SPECIFIED:
   1A. ALL RESISTORS IN OHMS 1/2W, 10%.
   1B. ALL CAPACITORS IN MICROFARADS, 500V.
2. SQUARE( ) DESIGNATES PRINTED CIRCUIT CONNECTION ON PC800, ASSEMBLY NO. 950397.
3. THE VALUE FOR R829 IS SELECTED FOR THE 630, AND DEPENDS ON THE ANODE VOLTAGE OF THE BWO TUBE.

SCHEMATIC – ELEVATED SUPPLY

900673C

SHEET 1 OF 1

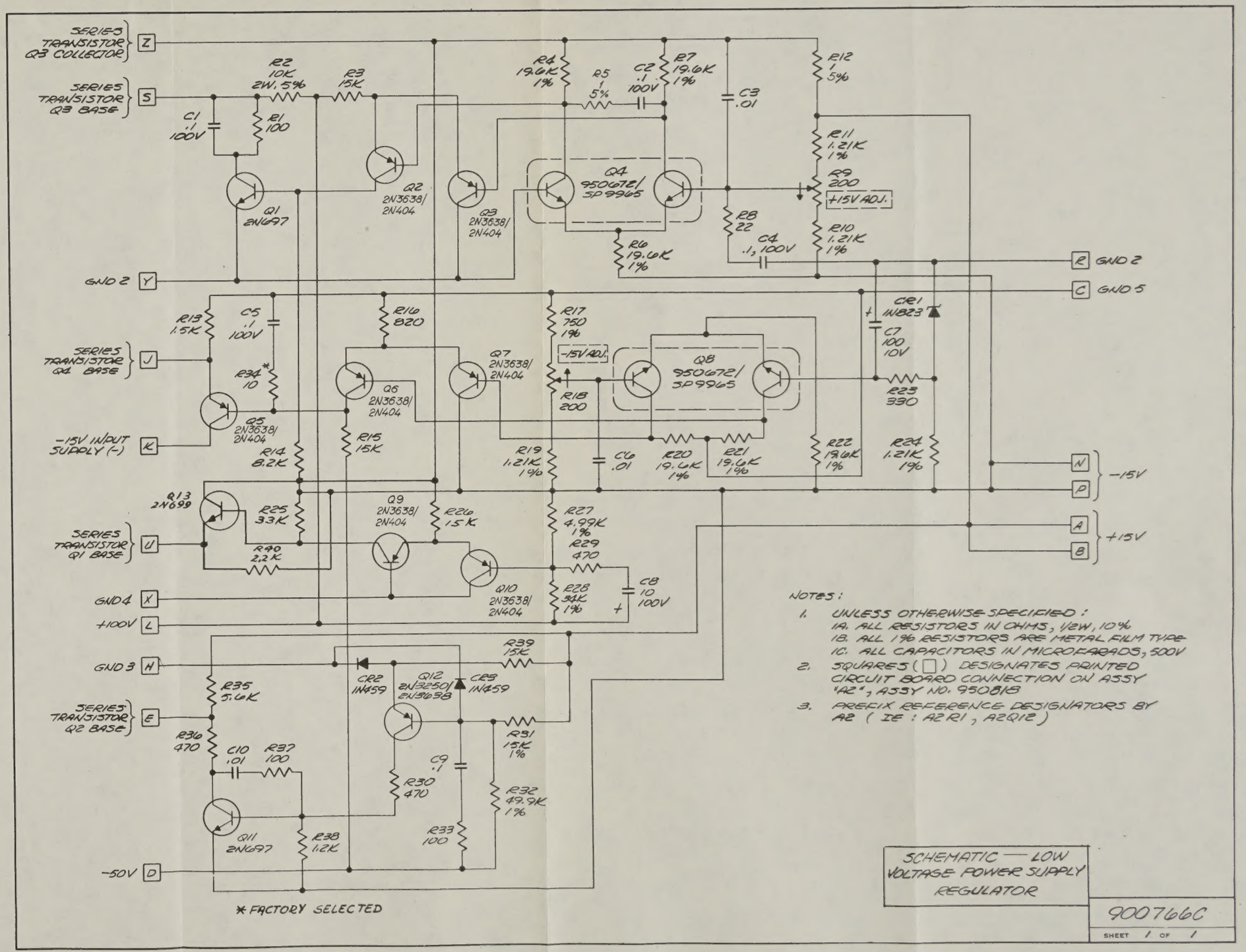
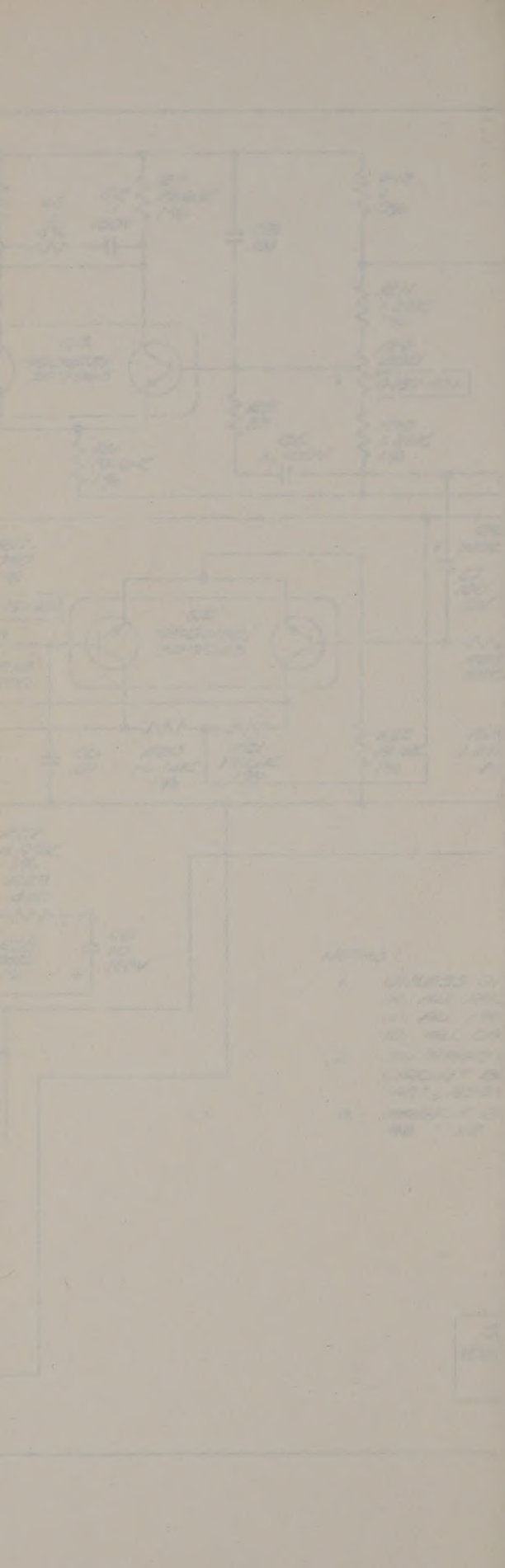


THERWISE SPECIFIED :
SISTORS IN OHMS, 1/2W, 10%
RESISTORS ARE METAL FILM TYPE
PACITORS IN MICROFARADS, 500V
(☐) DESIGNATES PRINTED
OARD CONNECTION ON ASSY
NO. 950818
EFERENCE DESIGNATORS BY
A2R1, A2Q12)

CHEMATIC — LOW
TAGE POWER SUPPLY
REGULATOR

900766C

SHEET 1 OF 1


SERIES TRANSISTOR Q3 COLLECTOR
Z
SERIES TRANSISTOR Q3 BASE
S
GND 2
Y
SERIES TRANSISTOR Q4 BASE
J
-15V INPUT SUPPLY (-)
K
SERIES TRANSISTOR Q1 BASE
U
GND 4
X
+100V
L
GND 3
H
SERIES TRANSISTOR Q2 BASE
E
-50V
D
R2 10K 2W, 5%
R3 15K
C1 .1 100V
R1 100
Q1 2N697
Q2 2N3638/ 2N404
Q3 2N3638/ 2N404
R4 19.6K 1%
R5 1 5%
C2 .1 100V
R7 19.6K 1%
C3 .01
R12 1 5%
R11 1.21K 1%
R9 200 +15V ADJ.
R8 22
C4 .1, 100V
R10 1.21K 1%
Q4 950672/ 3P9965
R6 19.6K 1%
R
GND 2
C
GND 5
CR1 1N823
C7 100 10V
R13 1.5K
C5 .1 100V
R34* 10
Q5 2N3638/ 2N404
R14 8.2K
R15 15K
R16 820
Q6 2N3638/ 2N404
Q7 2N3638/ 2N404
R17 750 1%
-15V ADJ.
R18 200
Q8 950672/ 3P9965
R23 330
R19 1.21K 1%
C6 .01
R20 19.6K 1%
R21 19.6K 1%
R22 19.6K 1%
R24 1.21K 1%
N
P
-15V
Q13 2N699
R25 3.3K
R40 2.2K
Q9 2N3638/ 2N404
R26 15K
Q10 2N3638/ 2N404
R27 4.99K 1%
R29 470
R28 31K 1%
C8 10 100V
A
B
+15V
R39 15K
CR2 1N459
Q12 2N3250/ 2N3638
CR3 1N459
R35 5.6K
R36 470
C10 .01
R37 100
Q11 2N697
R38 1.2K
C9 .1
R30 470
R33 100
R32 49.9K 1%
R31 15K 1%
* FACTORY SELECTED
NOTES:
1. UNLESS OTHERWISE SPECIFIED:
1A. ALL RESISTORS IN OHMS, 1/2W, 10%
1B. ALL 1% RESISTORS ARE METAL FILM TYPE
1C. ALL CAPACITORS IN MICROFARADS, 500V
2. SQUARES (□) DESIGNATES PRINTED CIRCUIT BOARD CONNECTION ON ASSY "A2", ASSY NO. 950818
3. PREFIX REFERENCE DESIGNATORS BY A2 (IE: A2R1, A2Q12)
SCHEMATIC — LOW VOLTAGE POWER SUPPLY REGULATOR
9007666C
SHEET 1 OF 1